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PREHISTORIC HAFTED FLINT KNIVES.

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THE question of the function of the stone implements commonly called arrow and spear points has been a vexed one. There are few references by early writers to the use of chipped flint by the American Indians for other purposes than as points for projectiles. It is very probable, however, that a majority of these implements were used as knives or cutting tools and were attached to short handles of wood or antler.

Major Powell found such knives in use among the Pai Utes. Colonel Ray collected similar implements from the Hooper valley Indians of California, and there is in the Peabody Museum at Cambridge a fine collection of leaf-shaped jasper blades fastened with pitch and cord wrappings to short handles of wood. These were obtained from the Klamath Indians of southern Oregon.

The finding of a few similar tools with wooden hafts still attached in prehistoric burial caves, cliff houses, and graves, shows that such implements were in use in prehistoric times over a large portion of North America. Prof. F. W. Putnam

has described and illustrated hafted stone knives from graves in the Santa Barbara Islands and from prehistoric burial caves in the state of Coahuila, Mexico; also one knife with a handle of antler from a mound in Ohio.[1]

The blades of the eight knives from the mummy packs of the Mexican burial caves referred to above are chipped from light-colored chalcedony, the largest one being seven and one-fourth inches in length, and its greatest width being three and one-fourth inches. The smallest blade is three and one-fourth inches long and two and one-fourth inches wide near its base. The blades vary in form, some being proportionally short with rounding points, others being comparatively narrow and sharply

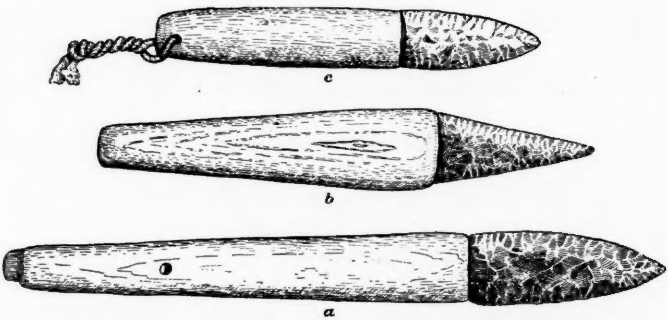

FIG. 1.—Prehistoric knives from the cliff houses, ½.

pointed. The hafts of these knives are of wood, about six inches in length, the majority of them being made of a section of a limb with the bark removed. One is fashioned from the discarded hearth of a fire-making set, and still retains the burnt depression in which the fire drill revolved. The thin base of the blades is inserted into a notch extending across the end of the haft, and is fastened with gum.

The knives from the Santa Barbara graves have small blades of flint of the leaf-shaped type. The hafts are of split wood, the blades being inserted into a notch at one end and secured with asphaltum.

[1] *Bulletin of the Essex Institute*, vol. xv, 1883; Wheeler's *Survey West of the 100th Meridian*, vol. vii; *Peabody Museum Reports*, vol. iii, p. 457.

The knife from the Marriott mound, Ohio, has a blade of black flint, nearly triangular in outline, inserted into a notch cut in the larger end of a curved antler prong. This knife and those from the Mexican caves, together with one from the Santa Barbara Islands, are on exhibition in the Peabody Museum.

While studying the remarkable collections from the cliff houses of the Southwest collected a few years since by the state of Colorado and by private individuals, the writer had unusual opportunities for examining a number of prehistoric flint knives

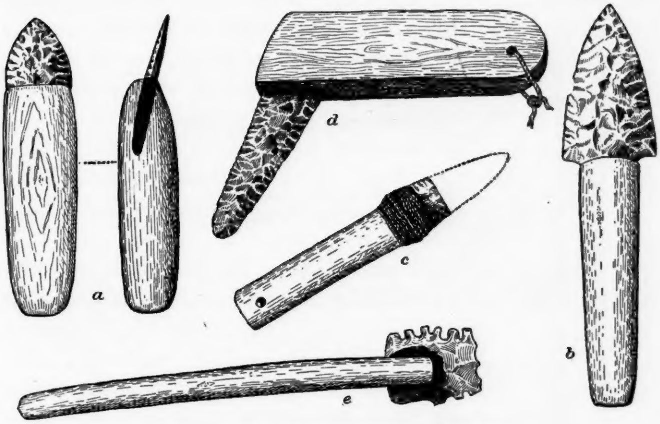

FIG. 2. — Prehistoric knives from the cliff houses, ½.

hafted in wooden handles. He is indebted to those in charge of the collections for permission to make the drawings accompanying this paper. Several of these knives are now in the Free Museum of Science and Art in Philadelphia.

The blades are chipped from different varieties of flint and chalcedony, and are of the common typical forms (leaf-shaped, triangular, stemmed, and notched) usually found in a collection of chipped implements. The handles are of wood, in most instances symmetrically fashioned and well finished, the blades being inserted into a deep notch and cemented with gum, probably of *Larrea mexicana*. In a few examples, windings of sinew or of cord made from yucca fiber furnish additional security.

The blades of the knives shown in Fig. 1 are attached to their handles with gum only. Their bases fit the notches snugly. The cement with which they are fastened projects slightly beyond the end of the haft and is pressed against the blade at either side. The blade of *a* is of black flint; *b* is also of dark flint, and *c* is chipped from gray chalcedony. A suspending cord of twisted cotton passes through the handle of *c*. The handle of *a* is also perforated for the passage of a cord.

The leaf-shaped blade of the knife illustrated in Fig. 2, *a*, is of light-colored chalcedony and is inserted for about half its length into the wooden handle, being firmly secured with gum. The drawing shows both front and side.

The beautiful knife shown in Fig. 2, *b*, has a blade of the stemmed variety, chipped from pink chalcedony. It is attached to the wooden handle with gum only.

The broken blade of Fig. 2, *c*, is fastened with gum. As an additional security it is wrapped with a cord of twisted yucca fiber. The handle is perforated for the passage of a suspending cord.

The unique example illustrated at *d* has a blade of dark flint secured at an angle to the well-made wooden haft. A cord of twisted yucca fiber passes through a perforation near the end.

The implement represented in Fig. 2, *e*, would perhaps be most correctly classed as a saw. The blade is of a type widely distributed but nowhere common. It is chipped from dark flint. The teeth are thin and sharp, and in the hands of a skilled prehistoric workman it has doubtless done good execution in wood, bone, and antler. The handle is a section of a limb or shoot, and the blade is secured with gum.

FIG. 3. — Prehistoric double-bladed knife from a cliff house, ½.

The double-bladed knife illustrated in Fig. 3 has for a handle a section of a small sapling or limb, with the bark

still adhering. Its length, including the blades, is eleven and one-half inches. The notched blades are fastened with sinew. A similar double-bladed knife is shown in the hand of a god issuing from the mouth of a serpent sculptured upon one of the lintels of a ruined temple at Yaxchilan, southern Mexico.

It is very probable that the implements shown in Fig. 4 were primarily intended as foreshafts for light spears projected with a spear thrower, a few examples of this ingenious device having been found in the cliff houses of the Southwest. These spear throwers have double finger loops, and are in other respects very similar to the ancient Mexican atlatl used by both Mexicans and Mayas, and represented in their sculptures. The foreshafts of the spears accompanying the atlatl in the carvings resemble

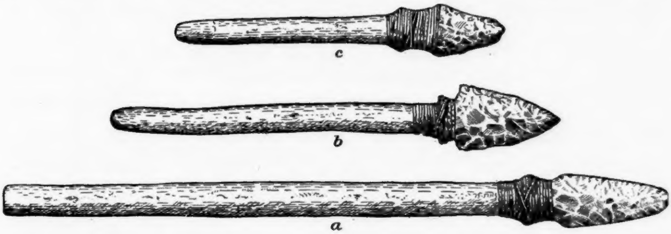

FIG. 4. — Prehistoric knives or foreshafts, ½.

those illustrated in Fig. 4. A foreshaft similar to Fig. 4, *b*, has the end opposite the point beveled for inserting into a socket at the end of the spear shaft. The lower end of Fig. 4, *c*, is also slightly beveled. The ends of *a* and *b* show no beveling, and these implements may have been intended for knives only; but if originally constructed for foreshafts to spears, it is probable, as they are detachable, that they were also used as cutting implements. The blades are secured to the hafts with sinew, no cement being visible.

In one of the collections was a spear-like implement tipped with a point of black flint closely resembling in form the knife blade illustrated in Fig. 1, *b*. This was secured in the notch with cement and cord wrappings. The shaft, forty inches in length, is worked smooth and polished, its lower end terminating in a rounding point.

Besides the tools whose functions are indicated by their forms, as perforators, scrapers, etc., chipped flint was used in America for cutting implements and as points for various kinds of projectiles, including arrows, light spears thrown with a throwing stick, harpoons with detachable heads, hand lances, small javelins, and thrusting weapons; but the greater number of flint implements of the common types, of lengths varying from about two inches to seven inches, were probably used as knife blades. Nor are we safe in assuming that the stemmed and notched forms were all projectile points, as an examination of Fig. 2, *b*, and Fig. 3 will show. It is of course impossible with our present knowledge to classify correctly all forms of chipped implements, but a study of the few prehistoric hafted examples known will materially aid us in the work.

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ON THE AFFINITIES OF CERTAIN ANOMALOUS DICOTYLEDONS.

DOUGLAS HOUGHTON CAMPBELL.

THERE is still a difference of opinion among botanists as to the relationship between the two great divisions of angiospermous plants, monocotyledons and dicotyledons. The two groups have evidently been derived from a common stock, but which branch is the older is still somewhat doubtful.

Among the genera commonly referred to the dicotyledons are several which differ from the typical forms both in the structure of the flowers and in the character of the tissues, especially the structure and distribution of the vascular bundles. Among these anomalous dicotyledons may be mentioned the Nymphæaceæ, certain Ranunculaceæ (Actæa, Thalictrum), and among the Berberidaceæ, Podophyllum, Diphylleia, and Caulophyllum.

A recent paper [1] on the embryo of Nelumbo has called attention to the importance of a thorough study of these anomalous genera, whose embryogeny is almost completely unknown.

The result of Lyon's examination of Nelumbo was the discovery that the apparently dicotyledonous embryo has really but a single cotyledon and resembles that of the aquatic Alismales, an order of monocotyledons that shows numerous analogies with the Nymphæaceæ.

This interesting discovery suggested to the writer the advisability of looking up what had been already done with the study of the embryos of some of the other forms referred to, and although the results of these inquiries have been very incomplete, they have revealed a number of extremely suggestive facts, which are here given, and which emphasize the desirability of more thorough work in the same direction.

[1] Lyon, H. L. *Minnesota Botanical Studies*, Ser. 2, pt. v, 1901.

NYMPHÆACEÆ.

In several respects the Nymphæaceæ suggest the Alismales, rather than the dicotyledons, with which they are usually associated. Some of the earlier botanists, among them Jussieu, considered the Nymphæaceæ as true monocotyledons; but all later botanists have agreed in placing them with the Polycarpicæ, or Ranales, among the most primitive of the dicotyledons. The discovery that Nelumbo has a monocotyledonous embryo at once raises the question whether the other genera are also monocotyledonous. The structure of the flowers, especially in the simpler genera, Cabomba and Brasenia, is very much like that in some of the Alismales, and the character of the vascular bundles, as well as their arrangement in all the Nymphæaceæ, is similar to that in the typical monocotyledonous stem. The form of the leaves, also, is often very suggestive of the sagittate leaves of Alisma or Sagittaria. This is seen in Nuphar, especially when growing in shallow water, and the early leaves of other Nymphæaceæ (Fig. 1) are remarkably similar to those of Sagittaria. Whether or not this resemblance of the young leaves of these Nymphæaceæ to those of the Alismales is really an indication of relationship, it is worth noting in connection with the other points of resemblance.

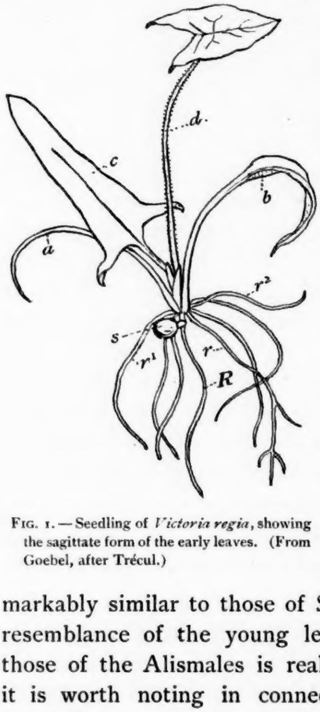

FIG. 1. — Seedling of *Victoria regia*, showing the sagittate form of the early leaves. (From Goebel, after Trécul.)

From Lyon's studies upon the embryo of Nelumbo it appears that in this genus the apparent two cotyledons are the result of a bifurcation of a single cotyledon. The stem apex arises laterally as in typical monocotyledons, and, as in these, the

cotyledon enwraps the plumule, which becomes largely developed. In Aponogeton, one of the Alismales, the sheathing base of the single cotyledon develops a pair of stipule-like lobes, which remotely suggest the two large lobes described for Nelumbo.

Whether the other Nymphæaceæ will show a monocotyledonous embryo remains to be seen, and the removal of the family to the Alismales is, perhaps, premature.

Ranunculaceæ.

A number of Ranunculaceæ resemble superficially the Alismales, especially as regards the structure of the flowers. The genus Echinodorus, of the Alismaceæ, for instance, has flowers closely resembling those of Ranunculus. Other Ranunculaceæ —*e.g.*, Actæa, Thalictrum—have the vascular bundles arranged much as in the typical monocotyledons instead of in the single ring characteristic of the typical dicotyledons.

Ranunculus ficaria has but a single cotyledon, which it is usually supposed is the result of the abortion of one of two cotyledons; but this has not been demonstrated, and it is barely possible it may prove to be truly monocotyledonous. Certain peculiarities in the embryos of other genera, which will be referred to later, point to the possibility of the embryo in these forms also having but a single cotyledon.

One important difference, however, must be noted between the Ranunculaceæ and the Alismales or Nymphæaceæ. In the two latter groups the embryo in the ripe seed is large, with very little endosperm about it. In the Ranunculaceæ the embryo in the ripe seed is always minute and is surrounded by abundant endosperm.

Anomalous Berberidaceæ.

Under the Berberidaceæ are generally included several peculiar genera of somewhat doubtful affinities. Of these, Jeffersonia, Podophyllum, and Diphylleia are especially interesting, as they are all small genera of peculiar distribution, being

represented in eastern Asia and Atlantic North America, but not occurring elsewhere. This points to their being old types which have persisted in these two widely separated regions, and adds to the interest in their history.

The development of the embryo is quite unknown in all of them, but the germination has been observed in Podophyllum, both in our native *P. peltatum* and in the Asiatic *P. emodi*, which agrees closely with *P. peltatum*.

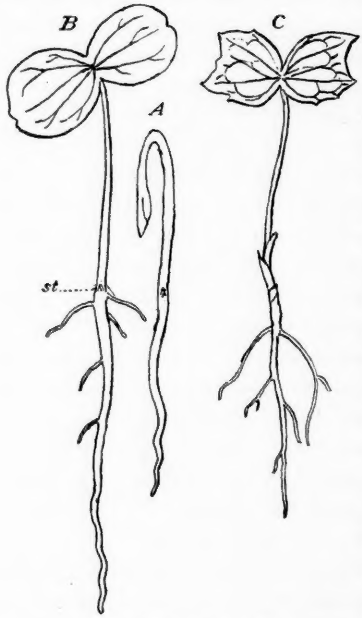

FIG. 2. — *A*, *B*, seedlings of *Podophyllum peltatum*, showing the coherent (?) cotyledons, and the plumule (*st*) at the base of the cotyledonary sheath. *C*, young plant in the second year; the binate leaf closely resembles the cotyledon. (After Holm.)

The latter species has been carefully studied by Holm,[1] and there are certain peculiarities in the germination, which, in view of the recent discovery in Nelumbo, are extremely significant. According to Holm (and the same is shown by Lubbock for *P. emodi*) there are apparently two cotyledons, with completely united, much elongated petioles, which form a hollow tube, at the base of which the plumule is placed (Fig. 2, *B*). The latter finally breaks through the base of the cotyledonary tube.

There would be nothing especially significant about this were it not found that the second leaf, as shown by Holm's studies, is deeply bilobed (Fig. 2, *C*) and resembles to an extraordinary degree the supposed *pair* of cotyledons. The thought was at once suggested, — Is not the supposed pair of cotyledons in Podophyllum really a single one, as in Nelumbo, the two apparent cotyledons being merely lobes of a single

[1] *Botanical Gazette*, 1899.

leaf? This view is much strengthened by the persistence of the bilobed form in the leaves of the young plant for several years, and the permanently binate leaves of the allied genera Jeffersonia and Diphylleia. The position of the plumule at the base of the cotyledonary tube suggests a possible lateral origin for this, as in typical monocotyledons and in Nelumbo. The character of the flowers and the tissues in Podophyllum and Diphylleia, as well as in Caulophyllum, are in accord with a possible monocotyledonous affinity for these forms. It is, at any rate, highly desirable that a careful embryological study should be made of these extremely peculiar plants.

The formation of a cotyledonary tube apparently similar to that in Podophyllum has been described for a number of widely separated forms, *e.g.*, Anemone, Delphinium, various Umbelliferæ, *Megarrhiza californica, Dodecatheon meadia.*[1] Whether in all of these there is really a coherence of two cotyledons must be determined by a study of the embryogeny.

It is evident that the last word has not yet been spoken as to the interrelationships of the angiosperms. The numerous studies upon the development of the embryo sac, which have appeared during the past few years, have shown that there is much more variation in the structures of the embryo sac than was supposed to be the case. The most marked departure from the angiospermous type is the genus Peperomia. The embryo sac of this genus has regularly sixteen nuclei instead of the eight usually present, and in this respect shows an approach to the condition obtaining among the gymnosperms and higher pteridophytes.

Peperomia, which appears to be genuinely dicotyledonous, nevertheless in the structure and distribution of the vascular bundles, as well as in the character and arrangement of the flowers, approaches some of the simpler monocotyledons, especially the Araceæ. It seems possible, as the writer has elsewhere suggested, that there may be two points where the two great divisions of angiosperms come together.

From the evidence at hand it would appear that the two phyla — monocotyledons and dicotyledons — are of about equal

[1] Holm, *loc cit.*, p. 422.

antiquity; but as a whole, the former have remained simpler than the dicotyledons. The scattered, closed vascular bundles probably represent a more primitive type of structure than the ring of open bundles characteristic of the more highly developed dicotyledons.

It is exceedingly important for a clear understanding of the affinities of such anomalous types as Podophyllum that a complete study should be made of the development of the embryo sac and embryo. Results of importance ought to reward the student who will make a critical study of the development of these puzzling forms.

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THE SKELETON OF THE HEAD OF INSECTS.

JOHN HENRY COMSTOCK AND CHUJIRO KOCHI.

THE skeleton of the head of an insect is composed of several sclerites more or less closely united, forming a capsule, which includes a portion of the viscera, and to which are articulated certain appendages.

The early entomologists, among whom were Fabricius (1775), Illiger (1800, 1806), Kirby (1802, 1826), Savigny (1816), Straus-Durckheim (1828), Burmeister (1832), Newman (1834), and Newport (1839), laid the foundation of our knowledge of the structure of this skeleton; and it is remarkable, considering the extent of entomological literature, how little has been added in this particular field since the publication of the article "Insecta" by the last-named writer.

Although comparatively little progress has been made in the study of the sclerites of the head during the last sixty years, very much has been learned by the workers of to-day regarding the development of this region of the body; and the time has come when, using the known facts of embryology as a starting point, one can hope, by comparative anatomical studies, to gain a clearer idea of the structure of the skeleton of the head than has been set forth as yet. To do this has been the aim of the writers of this paper.

I. AREAS OF THE EXTERNAL SKELETON.

In descriptions of insects it is necessary to refer to the different regions of the surface of the head. This has resulted in the establishment of a nomenclature, which, although based on the work of the early insect anatomists, is really of comparatively little morphological value; for but few of the primitive sclerites of the head have remained distinct, and some of them greatly overshadow others in their development. The result

is that in some cases a named area includes several sclerites, while in other cases only a portion of a sclerite is included.

This nomenclature, however, is sufficient for the needs of describers of species, and will doubtless continue in use. It is worth while, therefore, to review it briefly and to attempt where necessary to make it more definite.

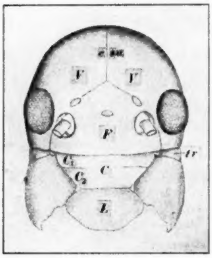

FIG. 1. — Head of a cricket.

The best landmark from which to start for this purpose is the *epicranial suture*, the inverted Y-shaped suture on the dorsal part of the head, in the more generalized insects (Fig. 1, *e.su.*). Behind the arms of this Y there is a series of *paired* sclerites, which meet on the middle line of the dorsal wall of the head, the line of union being the stem of the Y; and between the arms of the Y and the mouth there are typically three *single* sclerites (Fig. 1, *F, C, L*). It is with these unpaired sclerites that we will begin our definitions of the areas of the head.

The Front (*frons*, Kirby; *clypeus posterior*, Newport). — The unpaired sclerite between the arms of the epicranial suture (Fig. 1, *F*).

In the more generalized insects at least, if not in all, the front bears the median ocellus; and in the Plecoptera, the paired ocelli also. Frequently the suture between the front and the following sclerite, the clypeus, is obsolete; but as it ends on each side in the invagination which forms the anterior arms of the tentorium (Fig. 2, *at*), its former position can be inferred, at least in the more generalized insects, even when no other trace of it remains. In Fig. 2 this is indicated by a dotted line.

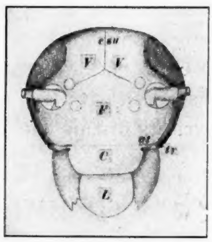

FIG. 2. — Head of a cockroach.

The Clypeus (*clypeus*, Fabricius; *chaperon*, Straus-Durckheim; *clypeus anterior*, Newport). — The intermediate of the three unpaired sclerites between the epicranial suture and the mouth (Fig. 1, *C*). To this part one condyle (the ventral) of the mandible articulates.

Although the clypeus almost always appears to be a single sclerite, except when divided transversely as indicated below, it really consists of a transverse row of three sclerites, — one on the median line and one on each side articulating with the mandible. The median sclerite may be designated the *clypeus proper*, and each lateral sclerite, the *antecoxal piece of the mandible*. Usually there are no indications of the sutures separating the clypeus proper from the antecoxal pieces; but in some insects they are distinct. In the larva of Corydalis the antecoxal pieces are not only distinct but are quite large (Fig. 3, *ac*, *ac*).

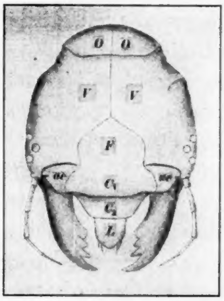

Fig. 3.—Head of the larva of Corydalis, dorsal aspect.

In some insects the clypeus is completely or partly divided by a transverse suture into two parts (Fig. 1). These may be designated as the *first clypeus* and the *second clypeus*, respectively; the first clypeus being the part next the front (Fig. 1, C_1) and the second clypeus being that next the labrum (Fig. 1, C_2).

There is a great lack of uniformity in the application of the term *clypeus*, arising from the fact that many writers apply it to the entire area between the epicranial suture and the labrum; either overlooking the fact that the part here designated as the front is a distinct sclerite, or, following Newport, terming it the *clypeus posterior*. But as the front and the clypeus (in the more restricted sense) pertain to different segments of the head, it is desirable to use distinct names for them; and as the names proposed by Newport are morphologically incorrect, the so-called clypeus posterior being in front of the so-called clypeus anterior, as will be shown later, it is doubtless better to use the older term *frons*, or *front*, for the sclerite next the epicranial suture, and to restrict the term *clypeus* to the part termed *clypeus anterior* by Newport.

The Labrum (*labrum*, Illiger). — A movable flap which constitutes the upper lip of the mouth (Fig. 1, *L*). The labrum is the last of the series of unpaired sclerites between the

epicranial suture and the mouth. It has the appearance of an appendage but is really a portion of one of the head segments.

The Epicranium (*épicrâne*, Straus-Durckheim). — Under this term are included all of the paired sclerites of the skull, and sometimes also the front. The paired sclerites constitute the sides of the head and that portion of the dorsal surface that is behind the arms of the epicranial suture. The sclerites constituting this region are so closely united that they were regarded as a single piece by Straus-Durckheim, who also included the front in this region, the epicranial suture being obsolete in the May beetle, which he used as a type.

The Vertex (*vertex*, Kirby). — The dorsal portion of the epicranium; or, more specifically, that portion which is next the front and between the compound eyes (Fig. 1, *V*, *V*). In many insects the vertex bears the paired ocelli. It is not a definite sclerite; but the term *vertex* is a very useful one and will doubtless be retained.

The Occiput (*occiput*, Kirby). — The hind part of the dorsal surface of the head. When a distinct sclerite, it is formed from the tergal portion of the united postgenæ described below (Fig. 3, *O*, *O*).

Fig. 4. — Head and neck of a cockroach.

The Genæ (*genæ*, Kirby). — The lateral portions of the epicranium. Each gena, in the sense in which the word was used by the older writers, includes a portion of several sclerites. Like *vertex*, however, the term is a useful one.

The Postgenæ. — In many insects each gena is divided by a well-marked suture. This led Comstock[1] to restrict the term *gena* to the part in front of the suture (Fig. 4, *G*), and to propose the term *postgenæ* for the part behind the suture (Fig. 4, *Pg*).

The Gula (*gula*, Kirby; *pièce basilaire*, Straus-Durckheim). — A sclerite forming the ventral wall of the hind part of the head in certain orders of insects, and bearing the labium or second

[1] Comstock and Kellogg. *Elements of Insect Anatomy.* 1895.

maxillæ (Fig. 5, *Gu*). In the more generalized orders, the sclerite corresponding to the gula does not form a part of the skull.

The Cervical Sclerites (*cervical sclerites*, Huxley). — Small sclerites found in the neck of many insects. Of these there are dorsal, lateral, and ventral sclerites; the lateral-cervical sclerites have been termed the *jugular sclerites* (*pièces jugulaires*, Straus-Durckheim) (Fig. 4, *es*, *em*).

Other Sclerites. — In addition to the areas and sclerites named above, the following sclerites will be described in later pages of this essay: the *ocular sclerite*, the *antennal sclerite*, the *trochantin of the mandible*, and the *maxillary pleurites*. These terms should be added to the list of those available for the purposes of systematic entomology.

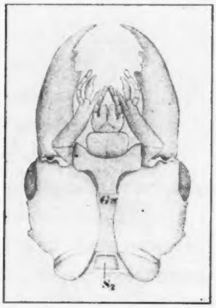

FIG. 5. — Head of Corydalis, adult, ventral aspect.

THE SEGMENTS OF THE HEAD.

The determination of the number of segments in the head of an insect is a problem that has been much discussed since the early days of entomology. The first important step towards its solution was made by Savigny (1816), who suggested that the movable appendages of the head were homodynamous with legs. This conclusion has been accepted by all; and as each segment in the body of an insect bears only a single pair of appendages, there are at least four segments in the head; *i.e.*, the antennal, the mandibular, the maxillary, and the second maxillary or labial.

As the compound eyes are borne on movable stalks in certain Crustacea, it was held by Milne-Edwards that they represent another pair of appendages; but this view has not been generally accepted. It is not necessary, however, to discuss in this place whether the eyes represent appendages or not; the existence of an ocular segment has been demonstrated in another way, to be discussed later.

This is the point to which the solution of the problem was carried by the methods of comparative anatomy. The existence

of four segments was demonstrated, and the presence of a fifth (the ocular) suggested. From this point the work has been carried on chiefly by the embryologists.

FIG. 6. — Embryo of a damsel fly (Calopteryx), after Brandt.

The existence in the embryo of distinct segments, each corresponding to a pair of mouth parts, was early shown. Among the better of the older figures for this purpose are those of Brandt ('69, Fig. 12) and of Packard ('71). Fig. 6, which is copied from Brandt, represents an early stage in the development of the embryo of a damsel fly (Calopteryx). In this stage the labial and maxillary segments are quite distinct, appearing to be body segments rather than cephalic. This doubtless represents a phylogenetic stage, in which the head proper consisted of fewer segments than it does in existing insects.

It was also found that the subœsophageal ganglion, which innervates the mandibles, maxillæ, and labium, is formed by the union of at least three pairs of primitive ganglia. Fig. 7, from Heider ('89), represents a stage in the development of Hydrophilus, in which these ganglia are still distinct, each pair of ganglia corresponding to a pair of mouth parts.

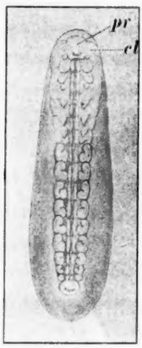

FIG. 7.—Embryo of Hydrophilus, after Heider.

So far the results of embryology merely confirm the conclusions of comparative anatomy. But the embryologists have also demonstrated the existence of vestiges of segments, which had not been recognized as such by the early writers.

In his work on the embryology of the honey-bee, Bütschli ('70) described a pair of evanescent appendages situated between the antennæ and the mandibles. Later these were observed by others, and writers began to refer to a "premandibular," or "intercalary," segment in the head of insects. More recently the appendages of this vestigial segment, which is properly termed the second antennal segment, were observed in the embryo of Anurida by Wheeler ('93) and by Claypole ('98).

They were also observed in Campodea by Uzel ('97). The last writer states that these appendages persist in the adult Campodea, and Folsom ('99b) says, "I may add that rudimentary chitinized intercalary appendages persist in adults of Tomocerus, Orchesella, and other Collembola."

Equally important evidence as to the existence of a second antennal segment in insects has been furnished by studies of the nervous system. It was shown by Viallanes ('87a) in his study of the structure of the brain (supra-œsophageal ganglion) of Vespa that there are three principal divisions in the brain of insects. These he named the *protocerebrum*, the *deutocerebrum*, and the *tritocerebrum*. Almost immediately after Patten ('88) demonstrated that the brain is formed from three pairs of primary ganglia; and the same fact was shown by Wheeler ('89). Viallanes also showed that the protocerebrum innervates the compound eyes and ocelli; the deutocerebrum, the antennae; and the tritocerebrum, the labrum. This demonstrates the existence of three premandibular segments: first, an ocular or protocerebral segment, without appendages, unless the compound eyes represent them (the supposed discovery of other appendages on the ocular segment by Carriere ('90) has not been confirmed); second, an antennal or deutocerebral segment, bearing antennæ; and third, a second antennal, or tritocerebral segment, of which the labrum is a part, and to which the so-called intercalary appendages doubtless belong. As Viallanes has shown that the tritocerebrum of Crustacea innervates the second antennæ, we are warranted in considering the tritocerebral segment of insects to be the second antennal segment.

The evidence thus far brought forward demonstrates the existence of six cephalic segments, — three innervated by the brain and three by the subœsophageal ganglion. We have now to refer to the evidence indicating the existence of a seventh cephalic segment.

The hypopharynx of insects is usually, in the Pterygota, a tongue-like organ lying below and projecting in front of the beginning of the alimentary canal. In the Apterygota it consists of three distinct parts, — a median organ termed the

"lingua" and a pair of organs termed "paraglossæ" by writers on the Thysanura and Collembola. As the term "paraglossæ" has long been used for a part of the labium or second maxillæ, Folsom ('00) justly maintains that it should not be applied to a part of the hypopharynx, and proposes for these paired organs the term *superlinguæ.*

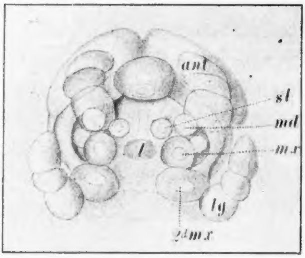

FIG. 8.— Head of embryo of Anurida, after Folsom.

In his work on the development of apterygote insects, Uzel ('98) showed that the lingua arises between the rudiments of the maxillæ; hence it may be regarded as pertaining to the sternum of the maxillary segment. Uzel also showed that the superlinguæ arise as a pair of appendages between the mandibles and the maxillæ. This indicates the existence of a segment between the mandibular and the maxillary segments.

Similar results were obtained by Folsom ('00) in his work on the development of the mouth parts of Anurida. Fig. 8 is copied from Folsom and illustrates the relative positions of the rudiments of the mouth parts. To Folsom also belongs the credit of completing the evidence of the existence of a superlingual segment, by demonstrating the existence of a pair of primary ganglia between those of the mandibular and of the maxillary segments (Fig. 9, *5*). And in a preliminary paper ('99b), he set forth the first complete account of what promises to be our final view regarding the segmentation of the head.

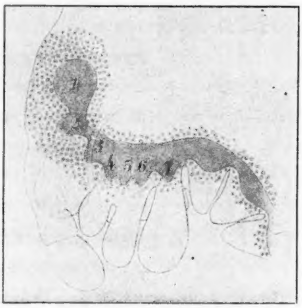

FIG. 9.—Section of the head of an embryo of Anurida, after Folsom.

In confirmation of the view that the subœsophageal ganglion consists of four pairs of primary ganglia, it should be mentioned that long ago Patten ('88) figured these ganglia. It has been believed, however, that

the pair immediately in front of the maxillary ganglia were the mandibular ganglia (see Korschelt and Heider, **'99b**, p. 326); but it is more probable that the first of these four pairs of ganglia (Fig. 10, *4*) pertains to the mandibular segment and that the second pair are the homologues of the superlingual ganglia figured by Folsom.

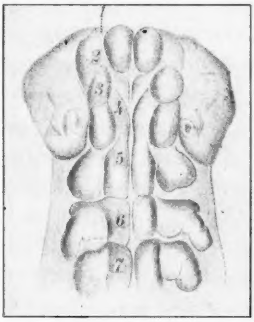

FIG. 10. — Head of embryo of Acilius, after Patten.

The seven segments of the head are designated as follows:

First, ocular, or protocerebral.
Second, antennal, or deutocerebral.
Third, second antennal, or tritocerebral.
Fourth, mandibular.
Fifth, superlingual.
Sixth, maxillary.
Seventh, labial, or second maxillary.

DIAGRAMS OF THE ELEMENTS OF THE HEAD.

The head of an insect consists of seven segments closely consolidated, greatly reduced in length, and, in the case of some, bent out of the original line. The morphological relations of these segments can be shown by representing them as distinct, of uniform size, and in a direct line. This is done in the accompanying diagram (Fig. 11, *A*).

Let us trace the steps by which this diagram was made. First, the outlines of the seven segments were drawn as if no

A

B

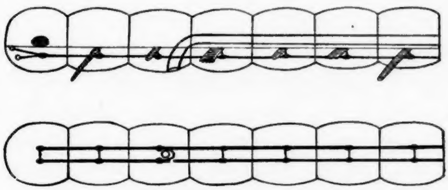

FIG. 11. — Diagrams of the elements of the head: *A*, lateral aspect; *B*, ventral aspect.

reduction or consolidation of any of them had occurred; at this stage the diagram might represent the cephalic end of an earthworm, except that the prostomium is not represented.

Second, a longitudinal line was drawn representing the line of separation of the sternal from the pleural elements of the segments; it is along this line that the appendages are borne. Third, the chain of ganglia were added, a pair of ganglia in each segment; as the nervous system is developed from the ectoderm on the ventral side of the body between the appendages, it is represented in the sternal portion of the preoral segments as well as in the postoral segments. The diagram being of a side view, only a single member of each pair of ganglia and longitudinal commissures are shown. Fig. 11, *B*, is a diagrammatic representation of a ventral view of the nervous system. Fourth, the compound eyes and the ocelli were represented in the first segment (Fig. 11, *A*), because they are innervated by the protocerebrum. The reasons for the exact positions within the segment assigned to these organs will be discussed later. Fifth, the position of the appendages was indicated, a pair to each segment except the first. It will be remembered that the antennæ are innervated by the deutocerebrum; hence they pertain to the second segment. Sixth, the mouth was represented as opening in the ventral wall of the third segment; this is in accordance with the results of the studies of Viallanes (**'87a**), who has shown that, although the third pair of ganglia enter into the composition of the supra-œsophageal ganglion, the commissure which connects them passes behind the œsophagus. This is shown in the second diagram. Although the position assigned to the mouth in these diagrams was suggested by the results of the studies of Viallanes, it is not in accordance with his conclusions; for he evidently believes that the mouth opens between the third and fourth segments.[1] Our view is based on the well-known fact that the mouth of the embryo is formed *in* the labral rudiment and not behind it.

The determination of the position of the mouth is one of the most striking of the results of the later studies of the head. Naturally the older entomologists believed that the mouth-opening was at the cephalic end of the body, and this effectually

[1] "La tête de l'insecte est formée par six zoonites; trois sont prebuccaux et trois post-buccaux." — Villanes (**'87b**, p. 117).

prevented a correct homologizing of the sclerites of the head. It is evident that the old belief is still held by many; thus Heymons ('95) designates what he believes to be the first segment the *primäres Kopfsegment oder Oralstück.*

The earliest suggestion of a different position of the mouth that we have met was by E. Ray Lancaster ('73), who refers to an "adaptational shifting of the oral aperture." The later writings contain many references bearing upon this, although the full force of them is evidently not appreciated by the writers. Thus it has been said by many that although the antennæ were doubtless originally postoral they have become preoral. The facts would be more accurately stated by saying that although the mouth was doubtless originally preantennal it has become postantennal. This, however, would only partially indicate the change that has taken place; for, as will be shown later, the antennæ have moved cephalad at the same time that the mouth has moved caudad.

The Structure of a Typical Segment.

In order to determine the homologies of the sclerites of the head, it is necessary to decide what sclerites were probably present before the consolidation and reduction of its segments took place. We have decided that the head is composed of seven segments; let us now determine the elements in the skeleton of a single segment. This necessitates a study of segments in other regions of the body.

In the abdomen it is evident that a reduction of certain parts has taken place, correlated with the loss of the abdominal appendages; it is to the thorax, therefore, that we must look for the more typical insectean segment.

The parts of a thoracic segment that are commonly recognized are those described by Audouin ('24): a ventral part, *sternite;* two lateral parts, *pleurites;* and a dorsal part, *tergite.*

These are most easily seen in the wing-bearing segments; but they can be recognized also in the prothorax of certain generalized insects. This is especially the case in many Orthoptera, as cockroaches and walking-sticks, where the

pleurites of the prothorax are distinct from the sternum on the one hand and from the tergum on the other; more often, however, the tergite of the prothorax is not separated from the pleurites. This is also the case in the segments of the head: sometimes the tergite is distinct from the pleurites; but more often the tergite is merely a continuation of the pleurites over the dorsal side of the segment. In such cases the combined lateral and dorsal parts are designated as the pleurites; for we find that they bear the most characteristic feature of the pleurites, the lateral apodemes, to be described later.

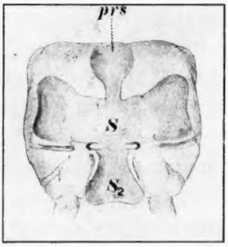

FIG. 12.—Ventral aspect of the metathorax of a nymph of Pteronarcys.

Equally important for the purposes of this study is the fact that each thoracic segment is composed of two subsegments. It is not necessary for us to decide in this place whether or not this indicates a fusion between two primary metameres, as has been suggested by various writers[1]; the essential fact which must be taken into account is the transverse division of each segment. The line separating the subsegments passes, on the pleural aspect, between the episternum and the epimeron; and, on the tergal aspect, between the scutum and the scutellum. On the sternal aspect, in most insects, the division is not easily recognized; but in certain Plecoptera and Orthoptera it can be readily seen.

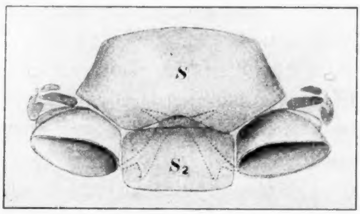

FIG. 13.—Ventral aspect of the metathorax of Stenopelmatus. The position of the furca within the body is represented by a dotted line.

Fig. 12 represents the sternite of the metathorax of a nymph of Pteronarcys, and Fig. 13 the same part of Stenopelmatus. In each case it can be seen that the sternite is composed of two distinct sclerites,—one lying between the episterna and one

[1] The reasons for believing that each segment is composed of two primary metameres have been well stated by Patten ('90, pp. 319, 320).

between the coxæ; the former pertains to the first subsegment, the latter, to the second.

In the furrow or suture between these two sclerites are the invaginations forming the furca of that segment. The position of the furca is, therefore, a good landmark for determining the line of union of the two sclerites forming a sternite, or, in other words, the division between the subsegments.

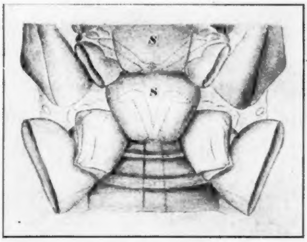

FIG. 14. — Ventral aspect of the meso- and metathorax of Gryllus; the positions of the furcæ within the body are indicated by dotted lines.

The second of the sclerites forming a sternite is smaller than the first, even in those insects where it is best developed; and in most insects it is greatly reduced or obsolete, so that the furca appears to arise from the caudal margin of the segment (Fig. 14). It is for this reason that the sternite of the second subsegment has been overlooked heretofore. The sternite of the first subsegment is retained in all insects, and is the sclerite to which the term *sternum* has been universally applied. The smaller sternite of the second subsegment may be termed the *sternellum* (Fig. 12, S_2; Fig. 13, S_2).

Sometimes, as in Pteronarcys, the cephalic portion of the sternum is more or less separate from the main part; this detached portion may be termed the *præsternum* (Fig. 12, *prs*). A *poststernellum*, corresponding to the postscutellum, has not been observed.

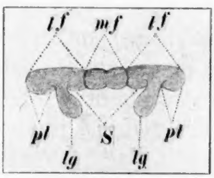

FIG. 15. — Diagram of a segment of an embryo, after Heymons.

It has been shown by Haase ('89) and Heymons ('95) that in a comparatively early embryonic stage each segment of the body is composed of three parts, — a median field and two lateral fields (Fig. 15), — and that the appendages are developed as evaginations of the lateral fields. Each sternite is therefore composed of three parts, — the portion derived from the median field of the segment, and, on each side, a portion derived from that part of the lateral field which lies

between the appendage and the median field. This portion may be designated the *lateral element of the sternite*. Such a division is well shown in the abdominal sternites of the adult Gryllus (Fig. 14).

More frequently, however, when a sternum in an adult insect is divided longitudinally it is by a single median suture, which perhaps represents the neural groove of the embryo.

A sternite of a subsegment may be composed, therefore, of either two or three elements : in the one case the sutures between the median field and the lateral fields are preserved ; in the other, a trace of the neural groove is indicated. But as a rule, each sternite is an undivided sclerite.

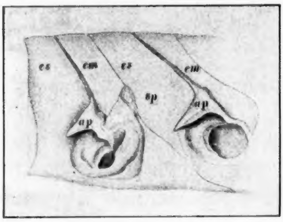

FIG. 16. — Ental surface of the pleurites of the meso- and metathorax of Melanoplus, showing the lateral apodemes.

In the same way that the position of the furca determines the line of union of the subsegments on the ventral aspect of a thoracic segment, the line of union of the subsegments on the pleural aspects is determined by the position of the lateral apodemes. Each of these is an invagination of the body-wall between the episternum and the epimeron. Fig. 16 represents the inner surface of the pleurites of the meso- and metathorax of Melanoplus and shows the form of the lateral apodemes (*ap*).

For the purposes of this paper, it is not necessary to discuss the structure of the tergal aspect of the typical segment beyond a reference to the median suture, which represents the line of the closure of the embryo. This suture has been well preserved in the head and thorax, as it is the chief line of rupture of the cuticle at the time of molting.

The relations of the appendages to a typical segment are illustrated by the accompanying figure (Fig. 17) of the base of a leg of a cockroach. Near the point marked *x* the coxa articulates with the ventral end of the foot of the lateral apodeme of the segment, *i.e.*, with the ventral end of the episternum and the epimeron. This may be termed *the pleural articulation*

of the coxa. In front of the coxa there is a triangular *trochantin* (*tr*), with its apex pointing towards the middle line of the body. Between the trochantin and the ventral arm of the episternum there are two sclerites, — one next the trochantin, *the antecoxal piece;* and one next the episternum, not yet named, which may be termed the *second antecoxal piece.* The antecoxal piece at its mesal extremity (*y*) articulates with the coxa. This articulation may be termed *the ventral articulation of the coxa.*

FIG. 17.—The base of a leg of a cockroach.

THE SCLERITES OF THE HEAD AND NECK.

The segments of the body of an insect do not fall into three well-marked groups, — head, thorax, and abdomen, — as commonly defined in the text-books. Between the head and the thorax there is a more or less distinct neck, which in some insects contains several sclerites. As we believe that these cervical sclerites form a part of the second maxillary or labial segment, it is necessary to include them in a discussion of the sclerites of the head. We shall return to them later.

If an embryo insect be examined after the appearance of the mouth and the appendages, the cephalic end of the body will be found to consist of a central swelling, the *procephalon* (Fig. 7, *pr*), and a large lobe on each side, the *cephalic lobes* (Fig. 7, *cl*).

The procephalon has been commonly described as the rudiment of the clypeus and the labrum. This is doubtless correct if the term *clypeus* be taken in the broader sense by which it includes the clypeus anterior and the clypeus posterior of Newport; and this is evidently the sense in which it has been used by nearly all writers on the embryology of insects. Hence, according to the nomenclature adopted in this paper, the procephalon is the rudiment of the front, clypeus, and labrum.

This conclusion makes evident the significance of the epicranial suture. The sclerites lying in front of the arms of

this inverted Y-shaped suture are those developed from the procephalon, while the stem of the Y represents the line of union of the cephalic lobes.

When we take into account the position of the mouth (see Fig. 11), it is evident that the parts developed from the procephalon pertain to the ventral aspect of the body. In the course of development there is a dorsal flexure of the cephalic region by which the preoral sterna are bent up towards the tergal aspect (Huxley, **'78**, p. 343); this has been described by several observers (see Korschelt and Heider, **'99b**, p. 302).

As a result of this dorsal flexure, the former most anterior part of the procephalon assumes a more backward position, which led to the part derived from it being termed by Newport the *clypeus posterior*. As this term is morphologically incorrect, we have adopted the name *front* for this part, and restrict the term *clypeus* to the clypeus anterior of Newport.

It seems obvious that the three sclerites derived from the procephalon, — the front, the clypeus, and the labrum, — represent the sternites of the three preoral segments.

As to the front, it bears the median ocellus, and, in the Plecoptera, the paired ocelli also; and as the ocelli are innervated by the protocerebrum, it is evident that the front is a part of the protocerebral segment.

In this connection reference should be made to a migration of the paired ocelli. The condition in the Plecoptera, where the front bears all the ocelli, is probably the most generalized; for in this order, as will be shown later, the most nearly primitive position of the antennæ is found; and, too, in this order the most generalized condition of the tracheation of the wings exists (Comstock and Needham, **'98**, p. 237). In the Orthoptera (Blattidæ and Gryllidæ) the paired ocelli are in the suture between the front and the vertex. In certain Ephemerida the paired ocelli are in this suture, while in others they have passed on into the vertex. In the more specialized orders, wherever we have been able to distinguish between the front and the vertex, we have found the paired ocelli in the vertex.

The labrum is innervated by the tritocerebrum; for this reason we regard it as the sternite of the tritocerebral segment,

or rather as a part of this sternite; for, as the invagination of the stomodæum is surrounded by the labral rudiment, the labrum represents only that part of this sternite that lies cephalad of the mouth.

The clypeus (clypeus anterior) is a sclerite between the front and the labrum; for this reason, we believe it to be the sternite of the intermediate of the three preoral segments, the deutocerebral.

We have described the sclerites derived from the procephalon as representing the sternites of the preoral segments. But strictly speaking, we believe that each represents only the median field of a sternite (Fig. 15, *mf*), and that the lateral elements of the sternites have not been separated from the pleural portions of the lateral fields of the segments; in other words, that the early embryonic divisions of the segments have been retained, and that those parts derived from the lateral fields of the segments form a single sclerite on each side of each segment.

In the ocular segment each lateral sclerite constitutes one-half of the vertex and the corresponding gena, the line of union of the lateral sclerites being the stem of the Y-shaped epicranial suture.

Each lateral sclerite of this segment bears a compound eye, except in cases where they have been lost and except in the larvæ of metabolous insects, in which the development of these organs is retarded; this is obviously a secondary condition, like the internal development of the wings in the same forms.

The position of the compound eye, in the lateral sclerite slightly removed from the middle field of the sternite (the front), is that in which one would expect to find an appendage, and it seems to us that the question whether or not the compound eyes represent the appendages of the ocular segment is still an open one.

Heretofore the chief reason for regarding the compound eyes as representatives of appendages has been the stalked condition of them in certain Crustacea; but later writers are inclined to regard the eye-stalks "as secondarily abstricted lateral portions of the head which have become independently movable" (Korschelt and Heider, '99a, p. 165).

We are inclined, however, to return to the old view; for we find that in many insects each compound eye is situated in the axis of an annular sclerite, which may be the basal segment of the ocular appendage. Certainly if the eyes were merely specialized portions of the lateral sclerites, we should not expect them to be surrounded by a ring-like suture, which in some cases is comparatively remote from the specialized portion of the body-wall that forms the eye.

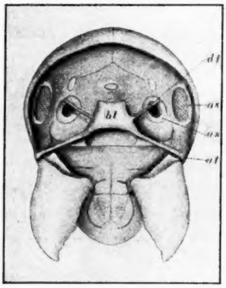

FIG. 18. -- Head of a cricket, ental surface of the dorsal wall.

These sclerites bearing the compound eyes may be termed *the ocular sclerites;* they are represented in Fig. 18, *os*.

Passing to the second segment, we find at the base of each antenna an annular sclerite (Fig. 18, *as*), which is distinct in comparatively few insects and which has not been described. It is most clearly shown in the Plecoptera (Fig. 19, *as*). This we believe represents the lateral field of the antennal segment, *i.e.*, the lateral element of the sternite and what is left of the pleural element of the segment, which is greatly reduced. This sclerite may be termed *the antennal sclerite.*

The position of the antennal sclerites should be discussed. If the clypeus represents the median field of the sternite of the antennal segment, as we believe, the primitive position of the antennal sclerites was laterad of the clypeus, and we should expect to find the rudiments of them in this position, *i.e.*, laterad of the procephalon, in the early stages of the embryo. Many observers, however, have described the antennæ as arising in a postoral position; how can this be explained? A study of the figures given by these authors [1] shows that while a line connecting the two antennæ would pass in some cases behind the mouth, it is by no means so clear that the basal part of the rudiment of the antennal sclerite does not abut against the procephalon. In fact, the very figures given to

[1] Weismann, '63, Fig. 22; Graber, '88, Figs. 1 and 2; Heider, '89, Fig. 102 (Fig. 7 above); Patten, '88 (Fig. 10 above).

support the view that the antennæ are postoral in the early embryo support the opposite view.

A migration cephalad of the antennæ has been noted by many observers; and it is obvious that the position of the antennæ in adult insects is more or less remote from the primitive position.

In the Plecoptera is to be found the most generalized condition of the antennal sclerites yet observed in postembryonic stages of insects (Fig. 19); here they are distinct sclerites, and are only slightly removed from the clypeus, compared with their position in the more specialized insects. Even here, however, they are opposite the front, having been pushed out of place by a migration of the mandibles and the antecoxal pieces, to be described later.

In most insects each antenna has migrated along the suture between the front and the gena, and occupies a position on the lateral border of the front remote from the clypeus. Even in so generalized an insect as a cockroach (Fig. 2), the antenna has reached a point opposite the cephalo-lateral angle of the vertex. Here it is remote from the anterior arm of the tentorium; while in Pteronarcys it is very close to it.

In the case of the second antennal segment, the reduction has been so great that we have been able to find in the Pterygota no trace of the parts derived from the lateral fields of the segment; the labrum is the only well-marked remnant of this segment represented in the skeleton; it is possible that the lateral elements are fused with the genæ. It is probable that a study of those Apterygota in which the second antennæ are retained will reveal the presence of distinct lateral sclerites pertaining to this segment.

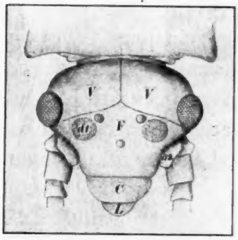

FIG. 19. — Head of a nymph of Pteronarcys.

In taking up the study of the postoral segments of the head, the subject can be treated most easily by beginning with the labial segment and proceeding forward to the point reached in the above discussion.

In the early embryonic stages the labial segment is obviously a body segment (Fig. 6, $2^d mx$); but in the course of the

development of the embryo it moves forward, and in adult insects it constitutes the dividing line between the head and the thorax, forming the neck. Its appendages, the second maxillæ or labium, however, have moved forward so that they are either loosely attached to the ventral wall of the head (Plecoptera, Orthoptera, *et al.*) or, in the more specialized orders, they contribute to the formation of the fixed parts of the head.

While the appendages of this segment have been retained and play an important rôle as a part of the mouth organs, the segment itself is greatly reduced, being represented by small and more or less detached sclerites, the cervical sclerites.

Straus-Durckheim (**'28**) suggested that the cervical sclerites represent the remains of two segments situated originally between the head and prothorax. Newport (**'39**) regarded them as detached portions of the prothorax; and Huxley (**'78**) wrote: "I think it probable that these cervical sclerites represent the hindmost of the cephalic somites." But we find no account of these sclerites that contains more than a suggestion regarding their homologies. No evidence has been brought forward to support any of the conclusions, beyond the position between the head and thorax occupied by these sclerites. We have been led to adopt the view put forth by Huxley for reasons that seem to us conclusive, and which we will now state.

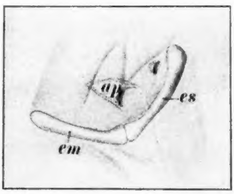

FIG. 20. — Lateral cervical sclerites of Melanoplus.

The cervical sclerites are best preserved in the Orthoptera. In this order a variable number occur in the ventral wall of the neck; two in each lateral wall; and in some forms, two in the dorsal wall.

Between the two lateral cervical sclerites there is in certain forms, as Melanoplus and Stenopelmatus, a prominent apodeme (Fig. 20, *ap*). This apodeme we regard as homodynamous with the lateral apodemes of the thoracic segments. Each of these apodemes is an invagination between an episternum and an epimeron; we, therefore, conclude that the anterior lateral

cervical sclerite is the episternum of the labial segment, and the posterior one the epimeron. This conclusion is confirmed by the fact that the posterior of the two lateral cervical sclerites articulates with the episternum of the prothorax, and the anterior one with what we believe to be the epimeron of the maxillary segment.

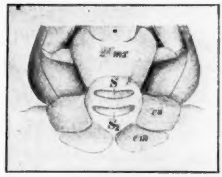

Fig. 21. — Ventral and lateral cervical sclerites of Periplaneta.

The ventral cervical sclerites in this order are either two in number, Periplaneta (Fig. 21), or constitute two transverse series, Stenopelmatus (Fig. 22), Gryllus (Fig. 23). We regard these as constituting the sternites of the two subsegments of the labial segment. If this view be correct, the anterior sclerite or series of sclerites represents the sternum of the labial segment, and the posterior the sternellum. The division of a sternite into a transverse series of either two or three sclerites is comparable with what frequently takes place in the sternites of the thorax and of the abdomen, already discussed on an earlier page.

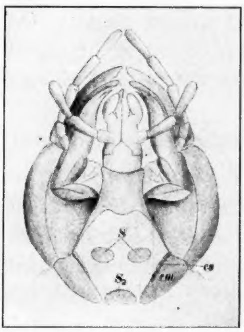

Fig. 22. — Head of Stenopelmatus, ventral aspect.

The appendages of this segment, the second maxillæ, project forwards from the front margin of the segment as a single organ, the labium. This anomalous condition is the result of a migration of the appendages forwards and towards each other and of a coalescence, which has been figured by many writers and often described, lately in detail by Deegener ('00). As a result of this coalescence the united cardines become the submentum, and the stipites the mentum.

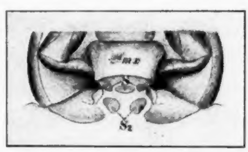

Fig. 23. — Ventral cervical sclerites of Gryllus.

In the more generalized insects a gula is not developed as such. We have devoted much study to the question of the homology of the gula and conclude that

it is the sternum of the cervical segment which has migrated cephalad and become a part of the skull. In Corydalis the sternellum of the cervical segment is retained back of the gula (Fig. 5, *S2*).

Although the maxillæ are well-developed organs, the maxillary segment itself is greatly reduced. The most conspicuous element of it is the lingua, the unpaired portion of the hypopharynx. This, as has been shown (Fig. 8, *l*), arises between the rudiments of the maxillæ and evidently pertains to the sternite of this segment.

The opening of the salivary glands is in the lingua. Carrière has shown that these glands arise as the spiracular invaginations of the prothorax, and that their openings migrate cephalad, and towards each other, finally forming a single opening in the lingua (Carrière and Bürger, **'97**). This explains the absence of spiracles in the prothorax, and is one of the most remarkable instances of the migration of organs and change in function yet described.

Regarding the maxillary pleurites of the completed head, almost nothing has been published. Huxley, in his description of the structure of the cockroach (**'78**), stated that the cardo of the maxilla is articulated "with a thin skeletal band which runs round the posterior margin of the epicranium." He made no suggestion regarding the homology of this sclerite; and subsequent writers do not appear to have done so.

This lateral band (Fig. 4, *m.em.*) is one of two sclerites, between which is the invagination which forms the posterior arm of the tentorium; the other of these two sclerites, the anterior one, is much more reduced than this one, still it can be seen in Periplaneta and in Gryllus. The articulation of the maxilla is at the ventral end of these sclerites just ventrad of the invagination between them, the open mouth of which is very conspicuous in the more generalized insects.

The relation of these parts corresponds exactly with what exists in a thoracic segment, where each leg is articulated just ventrad of the lateral apodeme, which is an invagination between the episternum and the epimeron. Evidently the band described by Huxley is the epimeron of the maxillary segment,

the thinner band in front of the invagination is the episternum, and the invagination itself is the lateral apodeme of this segment.

From this it will be seen that the posterior arms of the tentorium are to be homologized with lateral apodemes instead of with spiracles, as is often done. It should be borne in mind, however, that the spiracles are lateral invaginations between segments, and that the lateral apodemes are invaginations in a similar position between subsegments (Fig. 16). If each segment consists of two consolidated metameres, the lateral apodemes and spiracles are homodynamous structures. The solution of this question must wait, however, the solution of the larger question, the structure of the segment in air-breathing arthropods ; we need not dwell upon it here.

The superlingual segment is so greatly reduced that we are able to find no trace of the lateral elements of it in the skeleton ; if they exist, they are inseparably united with the mandibular pleurites. The sternal elements are represented by that part of the floor of the mouth cavity that bears the superlinguæ; and the appendages of the segment, by the superlinguæ themselves. In the Pterygota these parts are greatly reduced and have received but little attention. Fig. 24 represents the hypopharynx of Melanoplus, in which the lingua is very prominent, and what we regard as the superlinguæ are reduced to a pair of small sclerites. As the superlinguæ have been carried into the mouth cavity by its invagination, they lie behind the lingua, although they originated in front of it. The superlinguæ are connected with the skull by a membranous portion of the body-wall, which, on each side, extends between the attachments of the maxilla and of the mandible.

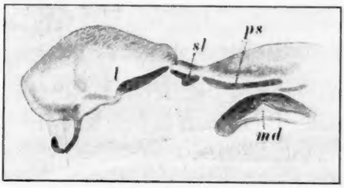

Fig. 24.— Hypopharynx of Melanoplus.

In the mandibular segment the pleurites are represented by the postgenæ, which, excepting the vertex and genæ, are the most prominent sclerites of the head in many Orthoptera.

The suture separating the postgenæ from the genæ is well-marked on the lateral aspect of the head in the Orthoptera. In most forms it is obsolete on the dorsal aspect but in a large South American cockroach that we have studied the postgenæ are separated from the genæ and vertex throughout their entire extent. Upon the presence or absence of this suture on the dorsal wall of the head depends the presence or absence of the so-called occiput; the occiput being the tergal portions of the postgenæ (Fig. 3, *O*, *O*).

In the ventral end of each postgena there is an acetabulum into which a condyle of the mandible fits (Fig. 25). Beginning in this acetabulum and extending dorsad there is a suture which divides the postgena into two parts; this suture is the more or less open mouth of an apodeme which extends into the cavity of the head.

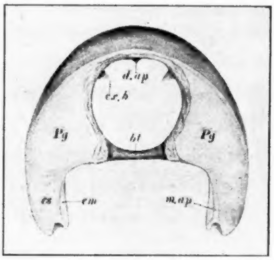

FIG. 25.— Head of a cricket, caudal aspect.

Here again the same relation of parts exists that is found in a thoracic segment. The mandible is the basal segment (coxa) of an appendage, which articulates with the ventral ends of two sclerites (episternum and epimeron), between which there is a lateral apodeme.

Thus we see that three of the head segments — the labial, the maxillary, and the mandibular — closely resemble a thoracic segment, in having on each side two sclerites, with an apodeme between, and an appendage below except in the case of the labial segment, where there has been a cephalization of the appendages.

In the floor of the mouth cavity of Melanoplus there is on each side just behind the superlinguæ a sclerite (Fig. 24, *ps*) which may represent a sternal element of the mandibular segment. The position of this sclerite farther in the mouth cavity than the superlinguæ is that which would be occupied by a mandibular sternite, as such a sternite must precede the superlinguæ in the course of the invagination of the mouth; equally suggestive is the fact that this sclerite is closely connected

with the mandible, joining it near the insertion of the flexor muscle. But in the present state of our knowledge little stress can be laid on supposed homologies of the parts of the pharyngeal skeleton; for it is evident that in this region sclerites are frequently developed secondarily.

The articulation of the mandible with the postgenæ is its pleural articulation; the ventral articulation appears to be with the clypeus in Periplaneta (Fig. 2), *i.e.*, with the sternite of the second segment in front of the mandibular segment. It is difficult to imagine the steps by which, in the course of the phylogenetic development of cockroaches, this condyle of the mandible could pass from one segment to another without interfering with the usefulness of the mandible during the transition period. This was for us a perplexing problem for a long time.

Later it was found that in Gryllus (Fig. 1) the mandible articulates with a small sclerite which is sometimes distinct from the clypeus. The same thing was found in the larva of Corydalis, except that here (Fig. 3, *ac*) the sclerite is large and clearly distinct.

As the ventral articulation of a coxa is with an antecoxal piece (see page 27), we regard this sclerite as the antecoxal piece of the mandible. In the course of the consolidation of the segments of the head and of the dorsal flexure of the sternites of the first three segments (the procephalon), the antecoxal piece of the mandible has been pushed out of its own segment past the labrum (the sternite of the second antennal segment) and, in Gryllus, nearly past the clypeus. Such a migration of the antecoxal piece could take place without interfering with the action of the mandible.

Doubtless a factor in bringing about these changes is the fact that while there has been a marked reduction in the length of the head segments (the entire head composed of seven segments being approximately of the same length as a single segment elsewhere), there has been no reduction in the width of the base of the mandible in biting insects. It is not strange, therefore, that the least firmly fixed point of articulation, the antecoxal piece, should be pushed out of its primitive position.

In most insects the antecoxal piece of the mandible coalesces with the clypeus, so that the mandible appears to articulate with this sclerite.

In some insects, as Orthoptera, there is a distinct sclerite between the mandible and the gena (Fig. 1, *tr*). This from its position on the cephalic side of the base of the mandible between the pleural and ventral articulations must be regarded as the *trochantin* of the mandible.

This completes our account of the sclerites found in the external skeleton of the head of the more generalized insects. A *résumé* of the conclusions reached is indicated by the following table.

Segments, Sclerites, and Appendages of the Head.[1]

Segments.	Sclerites.	Appendages.
I. Ocular (Protocerebral).	Vertex and genæ. . . . . Front.	Ocular sclerites.
II. Antennal (Deutocerebral).	Antennal sclerites. . . . . Clypeus proper.	Antennæ.
III. 2d Antennal (Tritocerebral).	. . . . Labrum (Mouth).	2d Antennæ of Campodea *et al.*
IV. Mandibular.	Postgenæ. . . . . Antecoxal pieces. Pharyngeal sclerites.	Mandibles. Trochantin.
V. Superlingual.	. . . .	Superlinguæ.
VI. Maxillary.	Maxillary pleurites. . . . . Lingua.	Maxillæ.
VII. Labial.	Dorsal cervical sclerites. Lateral cervical sclerites. . . . . Ventral cervical scl. (Gula).	Labium.

[1] In each section of the middle column the dotted line indicates the division between the sternal and the lateral elements of the segment.

The Endoskeleton of the Head.

The endoskeleton of the head, like that of the thorax, consists of invaginations of the body-wall and of chitinized tendons. Some of these invaginations may be homodynamous with thoracic tracheæ, but others are obviously apodemes.

In many insects the mouths of some of the invaginations of the wall of the head remain open in the adult; in Corydalis, for example, they are very conspicuous.

Some of the apodemes remain separate, and are comparatively simple; but in the case of two or three pairs of invaginations, they meet and coalesce. In this way there is formed in the interior of the head a complicated structure which is known as the *tentorium* (Burmeister, '32, Vol. I, p. 25).

The three pairs of invaginations which may enter into the formation of the tentorium are known as the *anterior*, the *posterior*, and the *dorsal arms of the tentorium* respectively. The coalesced and more or less expanded tips of these invaginations constitute the central portion of the tentorium, and may be designated as the *body of the tentorium*. From the body of the tentorium there extends a variable number of processes or chitinized tendons.

The Posterior Arms. — The posterior arms of the tentorium (Figs. 26, 28, 29, *pt*) are the lateral apodemes of the maxillary segment. In many Orthoptera the open mouth of the apodeme can be seen on the lateral aspect of the head, just above the articulation of the maxilla (Fig. 4). In the Acrididæ (Fig. 28) these apodemes bear a striking resemblance to the lateral apodemes of the thorax (Fig. 16), except that the ventral process of the maxillary apodeme is much more prominent, and the two from the opposite sides of the head meet and coalesce, thus forming the caudal part of the body of the tentorium.

The Anterior Arms. — Each anterior arm of the tentorium (Figs. 26, 27, 29, *at*) is an invagination of the body-wall which opens on the cephalic margin of the antecoxal piece of the mandible (Fig. 2, *at*),[1] or, when the antecoxal piece is not distinct,

[1] Note that owing to the flexure of the head in those insects, like Corydalis, in which the mouth is at the anterior end of the body, the opening of the anterior arm appears to be on the caudal side of the antecoxal piece.

usually on the cephalic side of the cephalo-lateral angle of the clypeus (Fig. 2, *at*). (It should be borne in mind that the cephalic margin of the clypeus is that margin which joins the front; that morphologically the labrum is caudad of the clypeus.)

It has been shown by Carrière and Bürger (**'97**) that the position of this invagination in the young embryo indicates that it is the spiracle of the mandibular segment. It is easy to see that the migration cephalad of the antecoxal piece of the mandible, already described, would push this invagination into the position which it occupies in the adult insect.

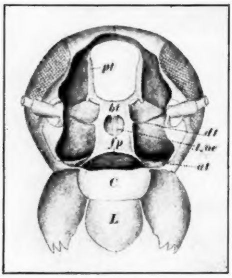

FIG. 26. — Tentorium of a cockroach, dorsal aspect.

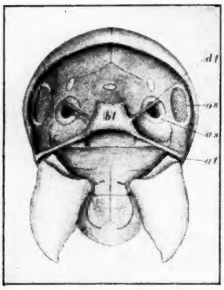

FIG. 27. — Part of the tentorium of a cricket, ventral aspect.

Bearing on this point is the fact that in Smynthurus, according to Lubbock (**'73**), the spiracles "open on the inner side of the bases of the mandibles." It remains to be determined whether in this case the anterior arms of the tentorium are wanting or not. Folsom (**'00**) found that, although the three pairs of arms are present in the collembolan Orchesella, the anterior arms are wanting in Anurida. In Orchesella where the anterior arms are present they are described by Folsom (**'99a**) as being joined to the paraglossæ (superlinguæ). But as the invaginations forming the anterior arms arise cephalad of the mandibles (Carrière and Bürger, **'97**), they cannot pertain to the superlingual segment.

Usually the invagination forming the anterior arms is extended to a greater or less degree along the sutures that converge upon it. This is well shown in Gryllus, where it is furnished with three buttress-like extensions: one along the suture between the front and the clypeus; another between the front and the gena; and a third between the gena and the trochantin of the mandible.

In the cockroach (Fig. 26) the buttress of the anterior arm that extends along the suture between the front and the gena is twisted in a way that suggests that it has been pulled out of place by the migration of the antenna. If we imagine the antennal sclerite pushed into a position which would untwist this buttress, it would bring this sclerite opposite the clypeus, that is, in its assumed primitive position.

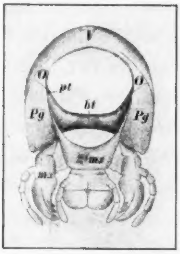

Fig. 28. — Head of Melanoplus, caudal aspect.

In the forms upon which the study is chiefly based, — the Plecoptera, the Orthoptera, and the Neuroptera (Sialidæ), — the antecoxal piece of the mandible is joined to the clypeus near its cephalo-lateral angle as described above. But in the Hymenoptera that we have studied it is joined to the caudo-lateral angle of the clypeus very near the labrum. A result of this in some forms is that the point of invagination of the anterior arm is remote from the front, as in the ants, although even here the buttress-like extension follows the margin of the clypeus and extends along the suture between the clypeus and the front. In other Hymenoptera the opening of the invagination has migrated to the cephalo-lateral angle of the clypeus and is thus remote from the articulation of the mandible ; this is the case in Bombus.

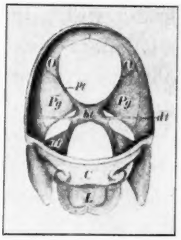

Fig. 29. — Tentorium of Melanoplus, cephalic aspect. The distal end of the dorsal arms detached.

The Dorsal Arms. — Each dorsal arm of the tentorium arises from the side of the body of the tentorium between the anterior and posterior arms and extends either to the front or to the margin of the antennal sclerite (Figs. 26, 27, 29, *dt*).

In the Plecoptera it appears to be merely a chitinized tendon, the peripheral end of which is less chitinized than the base and is only loosely attached to the skull. Here the point of attachment is on the front, some distance from the antennal sclerite, beneath a spot in the cuticle, which is marked by numerous polygonal areas. This spot is very distinct and bears some

resemblance to an ocellus (Fig. 19, *dt*). In the Orthoptera the peripheral end is more strongly chitinized than in the Plecoptera and firmly attached to the skull between the front and the antennal sclerite. It is small in the cockroaches, but is larger and easily seen in Gryllus (Fig. 27). In this case it bears some resemblance to an apodeme.

The resemblance to an apodeme is much more marked in some other insects. Thus in the Hymenoptera each dorsal arm is firmly attached to the skull near the antennal sclerite, and, in Cimbex for example, it is hollow and has an open mouth, appearing exactly like an apodeme.

It remains to be determined whether or not the dorsal arms in the Plecoptera are homologous with the apodeme-like dorsal arms in other insects, and, if so, which type is the more generalized.

The Body of the Tentorium. — This is the part to which the name *tentorium* was originally applied. It is the prominent bridge which divides the occipital foramen into two parts. The alimentary canal in entering the head passes above it, and the nervous system below it. It is formed of the coalesced and expanded tips of the arms of the tentorium (Fig. 28, *bt*).

The Frontal Plate of the Tentorium. — In the cockroaches the anterior arms of the tentorium meet and fuse, forming a broad plate situated between the crura cerebri and the mouth; this plate may be termed the *frontal plate of the tentorium* (Fig. 26, *fp*). On each side, an extension of this plate connects it with the body of the tentorium; these enclose a circular opening through which pass the crura cerebri.

The Tendons of the Œsophageal Muscles. — Muscles extend from the body of the tentorium to the œsophagus, passing between the crura cerebri. The tendons connecting these muscles with the body of the tentorium are frequently chitinized. In Pteronarcys there is a single chitinized tendon; in Periplaneta there are two (Fig. 26, *t.oe*).

The Tendons of the Flexors of the Head. — These arise from the lower surface of the body of the tentorium and extend caudad. Sometimes, as in Stenopelmatus, they are large and strongly chitinized.

The Tendons of the Extensors of the Head. — These are strongly developed in Gryllus; they project into the occipital foramen (Fig. 25, *ex.h.*).

The Dorsal Apodeme of the Head. — This is also well developed in Gryllus (Fig. 25, *d.ap.*).

The Lateral Cervical Apodemes. — These have been described above (see Fig. 20, *ap*).

The Mandibular Apodemes. — These also have been described above (see Fig. 25, *m.ap*).

In this study of the skeleton of the head our attention has been confined almost entirely to representatives of the more generalized orders of insects. We have felt that to do so was the surest way to gain an idea of the fundamental plan of structure. The working out of the ways in which this plan has been modified in the more specialized groups of insects must be left for the future and perhaps for other workers.

LIST OF ABBREVIATIONS.

ac.	Antecoxal piece.
ant.	Antenna.
ap.	Apodeme.
as.	Antennal sclerite.
at.	Anterior arm of the tentorium.
bt.	Body of the tentorium.
C.	Clypeus.
C_1.	First clypeus.
C_2.	Second clypeus.
cl.	Cephalic lobes.
d. ap.	Dorsal apodeme.
dt.	Dorsal arm of the tentorium.
em.	Epimeron.
es.	Episternum.
e. su.	Epicranial suture.
ex. h.	Extensors of the head.
F.	Front.
fp.	Frontal plate of the tentorium.
G.	Gena.
Gu. .	Gula.
L.	Labrum.
l.	Lingua.
lf.	Lateral field.
lg.	Leg.
md.	Mandible.
m. em.	Maxillary epimeron.
mf.	Middle field.
mx.	Maxilla.
O.	Occiput.
os.	Occular sclerite.
Pg.	Postgena.
pl.	Pleurite.
pr.	Procephalon.
prs.	Præsternum.
ps.	Pharyngeal sclerites.
pt.	Pcsterior arm of the tentorium.
S.	Sternum.
S_2.	Sternellum.
sl.	Superlingua.
sp.	Spiracle.
t. oe.	Tendons of the œsophageal muscles.
tr.	Trochantin.
V.	Vertex.
2d mx.	Second maxillæ or labium.

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ON THE HABITS OF THE KANGAROO RATS IN CAPTIVITY.

DR. R. W. SHUFELDT.

SOME time during the early part of the month of June or the latter part of May, 1901, Mr. Edward S. Schmid, a dealer in pets and animals, with an establishment at 712 Twelfth Street, Washington, D.C., received from one of his collectors in Kansas some two dozen specimens of "kangaroo rats." At first glance I did not recognize the species; but Mr. Schmid, with his usual generosity, presented me with three of the finest specimens in the lot, — two males and a female.

Upon taking these to my study I consigned them to a roomy cage with an inch or more of soil on the bottom of it, and I soon found that these very interesting little mammals fed with great avidity upon hemp and canary seed mixed up with a supply of wheat grains. They also drank freely of water placed for them in little china vessels.

After they had been in my possession a day or two, I found they had become sufficiently accustomed to my presence and handling to allow me to make the attempt to obtain photographs of them. This I undertook on two separate occasions, selecting for the purpose the darker and better marked male animal of the trio. Both times I succeeded in obtaining life-size pictures, and the reproductions of my results, reduced rather more than one-half, illustrate the present article. Fig. 1 represents the animal as he appears when asleep during the daytime, and Fig. 2 shows him when wide awake and engaged in busily nibbling upon a piece of root at the entrance of a shallow burrow he had dug for himself. As my methods of obtaining such photographs as these have been fully set forth by me during the past year or two in the technical journals devoted to scientific photography in this country and abroad, it will not be necessary to touch upon that question here.

Upon exhibiting my photographs to Mr. Gerret S. Miller, Jr., of the Mammal Department of the United States National Museum at Washington, D.C., he at once pronounced them to be specimens of the kangaroo rat described by Dr. J. A. Allen as *Perodipus richardsoni*, a species, so far as at present known, confined to Indian Territory, Kansas, and Oklahoma.

During the last sixteen or seventeen years the number of new North American species of jumping mice and kangaroo rats described by our mammalogists has been something phenomenal.

FIG. 1.—*Perodipus richardsoni* (Allen). ♂ (asleep). Less than ½ nat. size.
Photographed from life by the author.

Other genera have been similarly increased. When the United States National Museum published its provisional list of mammals of North America in 1884 (*Proc. U. S. Nat. Mus.*, Vol. VII, Appendix, p. 585), there were but two subspecies of Dipodomys recorded, and but one species of Zapus. If we turn now to the excellent volume published by Mr. D. G. Elliot, curator of the Department of Mammals of the Field Columbian Museum of Chicago (Zoöl. Ser., Vol. II, Chicago, 1901), entitled *A Synopsis of the Mammals of North America and the Adjacent Seas*, we find that there was recorded at the time of the issuance of that book no less than 23 kangaroo rats and 20

jumping mice (Zapus); 13 of the former are of the genus Dipodomys and 10 of Perodipus, the genus to which our present subject belongs. (See pp. 236, 237; Family (VI) Heteromyidæ; and for three views of the skull of *Perodipus agilis*, p. 237.) Other genera of this extensive group of our smaller rodents have likewise been largely added to, and a great many new species described of recent years. Mr. Elliot has since published a supplement to the volume here referred to, and this contains the descriptions of still other species.

I found my specimens of *P. richardsoni* extremely gentle in disposition, and any one of them would allow me to catch hold of it with my hand, and no amount of handling or even gentle squeezing could induce the little animal to bite or scratch. On one occasion I let them all out in my study, when it was very amusing to see their various antics and capers. They were as full of fun and play as could be, and soon seemed to take a genuine delight in my attempts to recapture them. They hopped about with great agility on their hind pair of kangaroo-like legs, while the little short pair of anterior limbs were curled inwards on the chest. At these times the animal's tail is simply dragged behind it, being in contact with the ground for its entire length. Its body is held obliquely, its axis making rather a small angle with the surface over which it is passing, but if occasion occurs for it to use its fore legs, they are brought into play at once, either for feeding, climbing, or burrowing. They are able climbers, and the rapidity with which they can dig a burrow in ordinary ground is astonishing. They use the fore feet to perform the digging part and the long and strong hind legs to kick the loosened soil out of their way behind, as it accumulates every moment or so. In soft soil one of these little mammals can put itself out of sight in less than a minute by digging, and it really seems to enjoy the operation. Among themselves they are somewhat inclined to be quarrelsome, biting and scratching one another sometimes without any apparent cause, while at other times they huddle together in a corner and sleep as peacefully as so many snails. The borders of the ears of one of these males, however, exhibit a few small healed-up nicks and notches that have very much

the appearance of having been acquired during combats with its fellows. During most of the day they pass the time in sleep, but they become very active towards dusk and probably are active all night. So it is that they rarely feed during the daytime, while after dark they are hearty consumers of anything that takes their fancy, especially of such grain and seeds as I have mentioned above. When sleeping they sometimes curl their long tails about them in a circle on the ground, while the nose and face is poked well down in between the fore legs, the body thus looking like a round puffball of hair surrounded

FIG. 2. — *P. richardsoni.* Same specimen as shown in Fig. 1. Feeding. Less than ½ nat. size. Photographed from life by the author.

by a single coil of the bicolored and longitudinally striped tail, the latter terminating in a brush at its end. Again they may sleep in the attitude shown in Fig. 1, where the animal had mounted a little log for the purpose and had been in sound repose for fully ten minutes, without moving, before I exposed my plate upon him. At other times they sleep upon their backs or sides, stretched out like little kittens or other small animals that assume such attitudes when enjoying a blissful doze in the warm sunshine.

This kangaroo rat is a very neat and cleanly little creature, frequently dressing its soft fur much after the fashion of the

common house mouse. Sitting up like a kangaroo, it will vigorously, and with both fore paws, dust its nose and face for a few seconds, when, with equal alacrity, it will pass to a general scratch of its sides and back, terminating the operation by starting at the root of its long and stout tail and rapidly passing the entire appendage through its fore paws to the very tip, while it is, as it were, at the same time briskly titillated with the lips and teeth at the front of the mouth. It is very amusing to observe the evident satisfaction it has in performing this act.

In addition to preening thus the face, body, and tail, it will, to dress the hair of the belly and back, push itself along in the dust or earth by means of its hind legs, and afterwards vigorously brush out the fur with its fore paws.

Another peculiar habit I observed in Perodipus was the way it had of using its fore paws for quickly pulling out the cheek pouches. By this means the pouches were completely turned inside out; they were then stretched, scratched, and dusted for a second or two, after which the animal tucked them back into position with equal rapidity.

As in the case with the majority of the Muridæ, when startled by sharp and sudden noises these nervous little animals will involuntarily spring from the ground for a centimeter or more ; when coming down again they will stand and gently grit their teeth together, while their eyes appear as though they were about to pop out of their orbits. At other times, particularly when feeding, the eyes are often kept not more than two-thirds open, and the animal then has an especially gentle look (Fig. 2).

Perodipus occasionally, at long intervals, gives vent to a peculiar note not altogether unlike the low sound of a cat when calling her kittens together, though not nearly so loud or distinct.

If kept in a roomy cage with five or six inches of soil on the bottom, where it is perfectly quiet and sunny, I see no reason why this species would not breed in captivity, and in any event they make very interesting and gentle little pets in confinement, quite equaling any of the squirrels, or even the famous dormouse of Europe, in this regard.

A CONTRIBUTION TO MUSEUM TECHNIQUE.

S. E. MEEK.

To exhibit fishes properly in a museum has been no easy task. Many methods have been devised, but none have as yet given universal satisfaction. Land animals, such as mammals, birds, reptiles, etc., are mounted and arranged in cases according to their natural order, to show relationship, or they are mounted in groups illustrating some of their habits and natural surroundings. These methods have received universal approval. With fishes the case is quite different. To mount them is difficult, and in most cases unsatisfactory, while many of the smaller soft-rayed fishes cannot be mounted. Painted plaster casts, or casts made of other material and painted, are used in some museums. In case nothing better can be had, these serve a good purpose and are especially desirable when a collection is to be exhibited at different times in various places. They are simply representations, and do not meet the desire of the visitor as do the real fishes themselves. A mounted fish is "a fish out of water," a fish robbed of his natural surroundings.

Three years ago we began some experiments in this museum to devise a metal case or vessel with a plate-glass front in which we could exhibit fishes in alcohol in a horizontal or natural position. A joint between the metal vessel and the plate glass, which would hold alcohol, and which would compensate at any temperature for the unequal expansion of the plate glass and metal, was devised by Mr. Wines, our building superintendent. Under his direction a vessel was made in December, 1898, with a plate-glass front of 18 by 36 inches. Nine species of sunfishes were placed in this vessel, and it was filled with 70 per cent alcohol, and put on the wall of one of our exhibition rooms. A few weeks later another case of 14 by 32 inches was made, and in it was placed a large blue-black trout from Lake Crescent,

Washington. These two cases have so far held satisfactorily, having been subjected to temperatures from 20° F. to 90° F. Two smaller cases put up at the same time have also proved very satisfactory.

In 1899 Dr. A. B. Meyer, director of the Natural History Museum of Dresden, made a tour of this country to study our museums and scientific institutions. It was my pleasure to escort him through the department of zoölogy in this museum. I called his attention to one of these cases and he remarked, "Very

good, but I like our method better." He kindly called my attention to an article, "Ein Beitrag zur Museumtechnik," by Dr. Max v. Brün, published in the *Abhandlungen aus dem Gebiete der Naturwissenschaften* (Bd. XIII), herausgegeben vom Naturwissenschaftlichen Verein in Hamburg, 1895. As this article is not easily accessible to all who are interested in the exhibition of fishes, I give here an abridged translation of it.[1]

The zoölogical museums are constantly progressing in their efforts to acquaint the public with the animal world by means of lifelike representations. Those animals which are robbed of their natural appearance, in a greater or less degree, by insufficient

[1] Published with the permission of Dr. Brün.

methods of preservation and preparation, are gradually being replaced by properly prepared material, so that museums are constantly asking less of the fancy or imagination.

The problem of preserving natural colors in alcoholic specimens is still unsolved, and yet the impressions which animal forms make on the eye, and through it on the understanding, depend much on color. It is not so much the task of our museums to preserve the natural color of an animal as to give it a lifelike appearance after the color has faded or has been lost. If for exhibition purposes we do this properly, our methods need not be questioned. To represent absolutely true to nature an individual specimen, is in most cases as impossible as it is unnecessary; for even in nature the individuals of any species are not all made according to the same mould, but they differ from each other within certain limits, not less in color than in other characteristics. The problem of preserving natural colors is reserved for preserving liquids, as Wiese-liquid, which by means of its chemical action seems well adapted for this purpose.

Preceding the opening of the Natural History Museum of Hamburg, it was my wish so to exhibit fishes that they should appear as lifelike as possible. The methods known to me up to that time did not appear favorable, so I began to think of something new. I did not believe fishes should be exhibited in a dry state, — *viz.*, embalmed or stuffed, — nor in tall bottles, standing on head or tail, but that they should be in a horizontal position, seemingly swimming in a medium representing water.

This was attained by means of oblong glass boxes filled with alcohol. It was then observed that the colors which gave the fish a true natural appearance were absent; this was to be helped only by painting, and accordingly an attempt was made with water colors which led to satisfactory results. It has so met the favorable judgment of visitors and professional men that I venture to believe myself in a position to commend this method as worthy of imitation.

In Bergen, Norway, the entire fish fauna has been set up in this way, and is very satisfactory. This method is also in use in the British Museum, as well as in German museums.[1]

The method consists in painting the fish, preserved in alcohol, on one side with water colors, as nearly natural as possible; and then

[1] The paragraphs in smaller type are from letters written to the author by Dr. Brün.

fastening it in a horizontal position by means of gelatin to the wall of the glass box, which is later filled with alcohol. A fish thus successfully prepared appears, to the visitors at least, as a living fish in water. Its lifelike appearance is much improved in the proper painting of the eye, which is not at all difficult. These water colors are durable in alcohol only when they are carefully selected, as has been proved by four (now ten) years' experience. A fish thus completed needs no repairing for some time. While in a general way this method can be recommended, yet in a few instances it may not work, especially when we are dealing with forms that have a bright, sparkling appearance, such as goldfishes. In such cases the Wiese-liquid seems to promise good results. A large goldfish preserved in this liquid for a period of two (now eight) years, though kept in the dark, has lost none of its brilliancy and beauty of color.

The using of oblong glass boxes is more expensive than glass bottles, but when we are dealing with a native fish fauna with comparatively few specimens of considerable size, this evil need not be permitted to play a large part. It is a fact that the mechanical possibilities of producing sufficiently large glass boxes for an available price are limited. The largest glass boxes prepared for this museum are 70 cm. long, and cost 24 marks each. Because of this, only the smaller specimens of the larger species, such as salmon and catfishes, can be easily exhibited. Very large specimens of these can be shown along with the smaller ones, either as mounted specimens or plaster casts, or they may be exhibited in glass boxes, made of glass plates cemented together.

The German marine exhibit in 1896 afforded me an opportunity to demonstrate the fact that these glass boxes with their contents could be easily transported from one place to another. Besides some small ones, the large glass boxes containing the salmon and the lamprey were taken from Hamburg to Berlin and returned in fine condition. The transportation was by boat on the Elbe, but, being taken to and from the boat by wagon, they were subject to considerable jarring.

The task of putting up one of the above-mentioned fishes may be divided into three parts: (1) preparation and preservation; (2) painting; and (3) setting up in the glass boxes.

(1) As the fish must be presented in a swimming position in the glass box with parallel walls, it must be preserved as perfectly as possible. In selecting a specimen one must pay special attention to form, color, proper size. Most of the fishes found in the markets are injured about the mouth, fins, or scales. Pretty badly injured

fins can be repaired. It is always best to select fishes to be mounted at the place of capture, and thus avoid the injuries occasioned by fish dealers in frequently throwing fishes from one vessel to another.

As only one side of the body is exhibited, it should be the better one, though as far as possible, for sake of uniformity, the same side of each should be presented to the visitor, as in my opinion it does not make as good an impression when some fishes are turned to the right and others to the left.

It is advisable to keep the live fish for some time in an aquarium, and make a study of its coloration. Then kill the fish in a 10 per cent solution of alcohol.

In using strong alcohol the mucous layer on the fish becomes too much hardened and cannot be removed.

After one half hour or so the mucous layer can be removed by means of a brush. Next lay the fish on its side in a shallow vessel, the bottom of which is lined with wax, and put on it some stronger alcohol. The fins are then spread, and held in position with insect needles. The torn fins are mended with fine silver wire, which is later removed. After the fish is in its proper position it is hardened by the gradual strengthening of the alcohol; the time required for this depends on the size of the fish, one of about two pounds' weight requiring about six days to bring the alcohol to 75 per cent.

In successful cases the form of the body is scarcely changed at all, and the eye fills its cavity as when the fish was alive. It is well, in case of larger fishes, to inject some alcohol into the vent after killing and to close it with cotton. The intestine should first be pierced, also the inner muscles of the body, with a fine scalpel, that the injected alcohol may fill the body cavity and more easily enter the flesh.

Externally the fish should not be injured in order to make the alcohol penetrate more rapidly, since where injured the fish would not get dry enough to paint, and injury to the farther side would interfere with fastening the fish to the gelatin. Should the belly still sink to an interfering extent, the proper roundness can finally be secured by stuffing it with cotton.

Later I have used formaldehyde 1 : 20, which I believe is to be commended to keep the body shape well. The fish is first killed in weak alcohol, then hardened in formalin, and later transferred to alcohol for permanent preservation. With the formalin treatment the scales of some species come off too easily.

(2) The painting of the fish faded by use of alcohol. For this purpose I have used water ground color and occasionally some marine blue. A few kinds of these colors are, however, to be avoided; in the first place, those containing lead, such as white lead and chrome yellow. The alcohol in which a fish has been for some time finally becomes somewhat acid, and at the same time the process of decomposition forming H_2S turns the colors containing lead dark or black. That is the way I was served in several cases; the pretty white belly of the fish finally appeared quite blackened. Chemical examination of the alcohol showed that there was present .034 per cent of free acid, supposed to be acetic acid (.348 gr. to one liter of alcohol). Under these conditions silver and brass bronze, usually appearing so durable, turned dark. Experiments with $H_2S + H_2O$ resulted in great durability of the same, but changed immediately after any trace of acid was added.

Aluminium bronze remained unchanged, even after the addition of considerable acid. Therefore one should use permanent white fine aluminium bronze and clear gold bronze. For use these are worked with a little liquid gum arabic.

Dr. W. G. Ridgwood has carried out in the British Museum very thorough tests for the most varied colors, as to their permanency in alcohol and sunlight, and has found decided differences.

The method of painting is as follows. The hardened fish is laid on a suitable surface. It is best to color the trunk and head first. In the mean time the fins must not be allowed to dry. The eye should be kept moist before and after painting, else these parts will dry out too quickly and shrink. If after a few minutes the body seems sufficiently dry, then one may begin with the painting, which after a little practice may be done without any special artistic ability. The paint cannot be applied as perfectly as it can be on paper, yet still in a sufficient degree to obtain the desired effect. This is most easily done in case of small scaled fishes, for example the tench; in other cases patience and practice lead to the goal. The process of painting is delayed very much because of one's being occasionally compelled to moisten the parts with alcohol, in order to observe the action of the colors, and eventually to change the tone of the same.

Because of the escape of fat or similar substances, the opercle, and many scales, and fin rays occasionally do not seem to take on the paint. These parts I have endeavored to cleanse with benzine. It

would perhaps be best to give them a coat of ox gall, which is used in painting on glass. The pupil should be colored a bluish black and surrounded with a golden circle verging into the iris; to the iris one can reproduce the niceties of its natural appearance, namely, its silver or gold glint, red circles and spots, black stripes, dots, etc. As soon as the paint is dry the eye should be moistened; otherwise it would sink, though a little sinking is hardly noticeable when the fish is put in alcohol.

Injured fins must be repaired before painting, which may be done by pasting on underside small pieces of silk paper with a thin solution of gelatin. The repaired places must be carefully dried before painting.

(3) The fastening of the fish in the glass.

The glasses used in our museum are blown oblong, with parallel walls. There are three special sizes produced by the glass factories of Gundlach & Müller of Altona-Ottensen. Their comparative sizes in centimeters and their prices, with 5 per cent discount, are as follows:

Length.	Height.	Depth.	Price.
35	20	9	8 marks
50	25	11	11 "
70	30	14	24 "

These glasses are unground: those with polished face are more expensive, but appear also much more elegant. The firm already mentioned has filled many orders for such glasses, and has of course much experience. Transportation of the same, even of the largest glass boxes, has been successfully made to America without material loss.

These glass boxes are closed with sheets of glass about 3 mm. thick and the edges ground to correspond to the thickness of the walls of the box, to which they are securely fastened with gelatin.

The closing of glass boxes, especially the larger ones, is not easy. When the collection is to stand some time undisturbed it is well to close the larger ones by simply covering with the glass lid. As the alcohol slowly evaporates it may be replaced. To open the glass boxes which have been closed with gelatin, it is better to cover the lid with layers of blotting paper and these with a wet cloth. After some time, say over night, the gelatin is softened, and the cover can be released with a little care.

In order to fasten the fish in a horizontal position in the glass case, it should first be laid on its broad side in the manner in which it is to be fastened in the glass. The tail should be supported with a piece of cork, or something of the kind, which is covered with

gelatin. Remove the fish and place where the head is to lay a layer of pretty stiff gelatin liquid, also place some on the cork; then lay the fish, previously well dried, on its unpainted side in its proper position in the glass. Soon the gelatin will be sufficiently hardened to permit the filling of the glass box with alcohol. If necessary, a hot knife may first be applied to the gelatin to fasten the fish securely to the glass. An eight-pound salmon fastened in this way has remained unchanged. The visitor sees nothing of this manner of fastening.

As I have in the foregoing only spoken of the painting of fishes, I should here like to say that other objects to be kept in alcohol may be treated in the same manner, — reptiles, amphibians, invertebrates, anatomical preparations, plants, etc.

In our museum at Hamburg there are numerous painted objects of this kind from both fresh and salt water, and though very imperfectly painted, they have a lifelike appearance. Especially is this true of water plants.

Such objects as sponges, which should have a uniform coloring, and which will stand being in water for a little while, may be put into a watery solution of the color, where they quickly become impregnated with it.

Moulded glass vessels are not as perfect as they should be; the surface is not exactly smooth; besides, it is made more or less dim by being in contact with the mould. The glass is thicker at the center and gradually thins out toward the edges and corners. The side of an oblong moulded glass vessel is quite inferior to a similar surface of polished plate glass. It is not necessary that a vessel be made entirely of glass; the top, bottom, two ends, and farther side may as well be made of any other suitable material. The side through which the observer must see the specimens cannot be too perfect.

A few years ago Mr. J. E. Benedict, of the United States National Museum, appreciating the value of a glass vessel whose sides (front one at least) are planes, experimented considerably, constructing vessels by cementing together sheets of plate-glass. To what extent he now regards this method as a success I am not advised. I never did believe his method received the recognition it deserved. It seems to me, however, that by using this method, the exhibition surface must necessarily be limited,

just as in the case of the cast-glass boxes. The idea of representing a fish in a museum in a fluid so that it "appears, to the visitor at least, as a living fish in water" is an excellent one. Following out this idea, our exhibition vessel partakes somewhat of the nature of an aquarium. A well-constructed aquarium needs but one glass side, and this side should be polished plate glass. It is necessary to make a joint between the material used and the plate glass which will not be effected by changes of temperature, and this presents no serious difficulties.

We have not tried the painting of fishes or fastening them in the vessel by means of gelatin. The use of round or oval glass bottles has been, within the past few years, quite universal. But both of these bottles are objectionable, because in them the fishes must stand on head or tail, and besides suffer more or less distortion. Among fishes are many peculiar and interesting forms, and this class of animals are as deserving of suitable methods of exhibition as are the other classes.

The time has certainly come when some method which will permit fishes to be placed in our museums as lifelike as possible, and one which will be economical and durable, will be much appreciated. If those who are interested in this question, and who have given it some attention, will publish the results of their experiments, it is possible that enough good features can be selected to discover the proper method.

NOTES AND LITERATURE.

GENERAL BIOLOGY.

Jenkins and Kellogg on Nature Study. — Under the title of *Lessons in Nature Study* Professors Jenkins and Kellogg of Stanford University have issued a volume (Whitaker & Ray, San Francisco) which should be of great service to teachers. It contains simple directions for the study of natural objects within reach of children. Among these are the dandelion, the mosquito, the toadstool, pond insects, spiders, crystals, ferns, birds, etc. These lessons are based on actual experience in dealing with children. The book is well illustrated and fairly printed.

D. S. J.

ZOÖLOGY.

"Bird Watching"[1] is the modest title of a new volume in the Haddon Hall Library. There are a dozen chapters, dealing with a variety of British birds, and constituting a record of patient "watching" of great plover on open, sandy wastes; wheatears on warren lands; great skuas and shags on far northern islands; winter birds at a straw stack, etc. The account of the actions of these and other birds often takes the form of long extracts from the author's note-book, but his personality and feeling for style give his observations an unusually bright and readable character. Occasionally he pushes his fancies to the verge of extravagance, and frequent digressions increase the burden of legitimate detail which the reader willingly bears. While there is constant evidence of painstaking accuracy of statement, the author's interest in the problems connected with the evolution of habit and plumage tempt him often into rather fruitless speculation.

The book must be very welcome to the lovers of British birds and will be read with interest not only by American ornithologists but

[1] Selous, Edmund. *Bird Watching.* The Haddon Hall Library. London, J. M. Dent & Co., 1901. 8vo, x + 347 pp., 14 illustrations.

also by many of the growing class of amateur naturalists. Detailed observation of familiar birds (such as Mr. Frank Bolles's paper on "Sap Suckers") will constitute an ever-increasing proportion of the literature of our popular ornithology, which has hitherto been marked by the not unnatural tendency to magnify the importance of a new or unfamiliar species.

The paper, print, and binding are extremely attractive. There are fourteen full-page drawings by J. Smit. These drawings, if necessarily less accurate than the now omnipresent photograph from nature, possess a welcome softness and repose.

R. H.

A New Economic Entomology.[1] — In a neat little volume of about three hundred pages, Prof. H. Kolbe has compiled an admirable treatise on *Gartenfeinde und Gartenfreunde;* it constitutes Vols. XXXIV–XXXVI of the great German "Garten-Bibliothek." This little venture of the author into the economic field will be of interest to American entomologists, as we are familiar with his great work, *Einführung in die Kenntnis der Insekten.* Notwithstanding the wealth of German literature on injurious insects and plant diseases, *Gartenfeinde und Gartenfreunde* fills an unoccupied niche, for it deals with both the animal (principally insects) and fungous enemies in a way suited to the needs of every German gardener.

After a brief discussion of the structure, the classification, and the various groups of insects, a dozen pages are devoted to remedial and preventive measures. Here the author introduces some of our American methods, but it is evidently unfamiliar ground. Sirrine's poisoned-resin mixture is recommended for garden caterpillars, and the Bordeaux mixture for nearly all fungous diseases; but our kerosene emulsion he calls "petroleumbrühe," and under "kerosene emulsion" he gives the formula for our potash whale-oil soap. Among remedies for plant-lice and thrips he mentions Paris green used dry. It is also an interesting fact that nowhere else in the book are any of our arsenical or other poisons recommended for killing insects; currant worms are to be shaken off onto a sheet instead of poisoned, and the universal poison spray of American orchardists for the codling-moth and other caterpillars is not mentioned. Most of the remedial measures involve hand work. The discussion of preventive measures is excellent, and the chapters on state, communal, and social

[1] Kolbe, H. *Gartenfeinde und Gartenfreunde. Die für den Gartenbau schädlichen und nützlichen Lebewesen.* Garten-Bibliothek, Bd. xxxiv–xxxvi. Berlin, Karl Sigismund, 1901. 8vo, iii + 318 pp., 76 figs.

institutions and regulations relating to plant protection in different countries will interest American readers.

The admirable method is followed of discussing the enemies under their respective food-plants, and over sixty pages are devoted to fruit-tree enemies. The San José scale receives more space than any other enemy except the grape phylloxera, and curiously enough the *Aspidiotus ostræformis* scale is called the "yellow European pseudo-San José scale." Injurious mammals and birds are briefly discussed, and then fifty pages are devoted to "Gartenfreunde," mostly the parasitic and predaceous insects.

I know of no similar work in any language covering so much ground so briefly and yet so well adapted for its field.

M. V. S.

The Circulation in the Nervous System. — In a pamphlet of some hundred and fifty pages bearing the above title, Dr. Gasser[1] develops what to his mind "is the only true conception that is in entire harmony with the established order of facts in the world of thought" concerning the action of the nervous system. Precisely what this conception is the author nowhere makes very clear, but so far as can be gathered his experience as a physician has profoundly impressed him with the belief that the nervous system works in a circular fashion. What circulates, whether matter or energy, and through what particular channels the circulation is accomplished, is left mostly to the imagination of the reader, though we are told that the evidence for this movement is as substantial as that for the circulation of the blood. As a figure of speech the circulation in the nervous system may be innocent enough; as a description of what actually takes place it is utterly without foundation. P.

The Oarfish, Regalecus, on the Coast of Southern California. — On the 25th of February a huge "sea serpent," with bright colors and the conventional mane, was reported in the newspapers as having come ashore near Santa Ana in southern California. No part of the animal was preserved, so far as known, but a good photograph was taken by Mr. G. T. Peabody of Santa Ana. It evidently represents an oarfish or herring king, some species of Regalecus. The fish was fifteen feet long and something over a foot in depth, weighing about five hundred pounds. The dorsal is considerably injured,

[1] Gasser, H. *The Circulation in the Nervous System.* Plattville, Wis., Journal Publishing Company, 1901. 156 pp.

but as nearly as can be counted the number of rays is about four hundred. The long spines on the head do not show in the picture. The species of Regalecus have never been defined, and the present one can hardly be certainly identified. It may be the New Zealand-Japanese-Indian species, *Regalecus russelli* or *argenteus*. D. S. J.

Notes on Recent Fish Literature. — In the *Annotationes Zoologicæ Japonenses* (Vol. IV, Pt. I), Dr. S. Hatta has a review of the Japanese lampreys, with notes on their local distribution and their anatomical structure. The new species, *Lampetra mitsukurii* Hatta, already characterized by Dr. Jordan, is here described. In another note Dr. Hatta discusses the metameric segmentation of the mesoblast in the lamprey and the lancelet. In the earlier stages the segmentation in the lamprey agrees with that of the lancelet; in its later stages with that of the higher craniota.

In the *Atti de la Società di Naturalisti*, etc., of Modena, Dr. Luigi Facciolà continues his valuable series of studies of the development of the larvæ of different forms of eels. These larvæ, known as Leptocephali, are ribbon-shaped, translucent, and soft, with very small heads. In their further development they undergo a shrinkage in size, attaining greater compactness of substance.

In the *Proceedings of the United States National Museum* (Vol. XXIV, pp. 33–132), Jordan and Snyder continue their series of monographic reviews of the fishes of Japan. Of the gobies, 57 species are described, representing 33 genera. Of these species, 21 are new and are here represented in the excellent drawings of Mrs. Chloe Lesley Starks.

We may here note that the generic name Chasmias, proposed by Jordan and Snyder for a genus of gobies in 1900 (page 761), is antedated by Chasmias Ashmead, a genus of Ichneumon flies published on page 17 in the same volume of the *Proceedings*. The genus of fishes, type *Chasmias misakius*, may receive the new name of Chasmichthys Jordan and Snyder. I am indebted to Mr. W. H. Ashmead for calling attention to the prior establishment of his genus. Of sea horses, pipefishes, and their relatives, nineteen species are described from Japan. Of these, seven are described and figured as new. The sea horses exist in especially large number and variety along the headlands washed by the warm "Black Current," or "Kuro Shiwo."

Professor Gilbert L. Houser, of the University of Iowa, contributes to the *Journal of Comparative Neurology* (Vol. XI, No. 2) a valuable monograph on the "Neurones of a Selachian," *Mustelus canis*. The anatomy of the nerve structures is given in great detail. Professor Houser shows commendable caution in refraining from "the tendency to elevate the results of specific methods into exclusive dogma." He closes his paper with these remarks suggestive of Golgi: "The knowledge which we possess, either anatomical or physiological, is not yet such as to permit us to interpret with certainty the greater number of the facts discovered, much less to attempt doctrinal constructions of a high order on the functional mechanism of the nervous elements."

In the *Bulletin of the United States Fish Commission* Dr. Eigenmann gives a useful account of the development of certain eggs supposed to be those of the Conger.

In the same *Bulletin* Dr. Hugh M. Smith gives a list of species of fishes the young of which are borne to Woods Hole in the Gulf Stream. Four of these, *Exonautes rondeleti*, *Ocyurus chrysurus*, *Scarus croicensis*, and *Sparisoma flavescens*, had not been previously recorded to the north of Florida. Among the other tropical forms are *Sardinia pseudohispanica*, *Mycteroperca bonaci*, *Mycteroperca venenosa*, *Lutianus apodus*, *Lutianus analis*, *Chætodon ocellatus*, *Chætodon bricei*, *Teuthis cæruleus*, *Teuthis hepatus*, *Teuthis bahianus*, *Lactophrys tricornis*, and *Scorpæna plumieri*.

In the *Annotationes Zoologicæ Japonenses* (Vol. III, Pt. IV), Dr. C. Ishihawa describes and figures two new gudgeons, *Leucogobio güntheri* and *L. jordani*. Both species belong to the rich fauna of Lake Biwa, the largest lake of Japan.

In the *Proceedings of the United States National Museum* (Vol. XXIV) Jordan and Starks give an account of the anatomy of Aphareus, a Polynesian genus of "red snappers," rare in collections.

In the *Proceedings of the United States National Museum* (Vol. XXIV) Jordan and Starks give an account of the Atherinidæ, or silver-sides, found in the waters of Japan. Five species are enumerated, four of them being new. Two new genera, Atherion and Iso, are characterized.

D. S. J.

Zoölogy of the Maldive and Laccadive Archipelagoes. — The results of the explorations of J. Stanley Gardiner in the Maldive and

Laccadive archipelagoes of the Indian Ocean[1] are appearing in a series of parts that closely resembles the series of Willey's "Results." The first part contains an eleven-page "Narrative and Route of the Expedition," with two maps. This shows that one who goes on such a journey may expect exasperating delays of weeks at a time. Next follows "An Account of the Coral Formations of the Indian Ocean," by Gardiner, which is not completed, but shows that atolls have been formed in regions of *elevation* (and not always of depression, as called for by Darwin's theory). The accompanying papers are by Borradaile (who was with Gardiner in the early part of his trip) on the "Land Crustaceans"; by Cameron on "Hymenoptera"; and by Punnett on "Nemerteans." In the last paper the first mesonemertean from the Indian Ocean is recorded, — a Cephalothrix. The prevailing genera are Eupolia, Cerebratulus, and Drepanophorus, — genera widely distributed. As to the Hymenoptera, Cameron says the known species are Indian forms of wide distribution in the Oriental zoölogical region, and all the genera are of universal distribution in temperate and tropical countries, — such familiar genera as Crabro, Bembex, Polistes, and numerous Apidæ. The most general interest attaches, however, to the paper on "Land Crustaceans." "Their numbers, their ubiquity, their activity, combine to give them a prominence which is all the more marked from the absence of so many other land animals of continental areas. They are the chief scavengers of the island, play a great part in the destruction or disintegration of fruits, and probably aid in the distribution of seeds. The work done by them in burrowing along the sandy lagoon shore has a possible importance not hitherto noticed." The paper gives an exhaustive account of the anatomy of Cœnobita, the land hermit crab. The gills seem to have undergone little modification, and the gill chamber is not at all a lung, but provision is made for keeping the gills moist by means of salt water apparently retained from possible rare visits to the sea. If this salt water is removed, a sticky fluid is exuded over the gills. If the gills be cut off, the crab lives by virtue of its abdominal respiration. Continuous submersion is fatal after a longer or shorter time, — one to six days. The habitation of the land hermit crab is very varied, — usually any kind of land or sea gastropod shell;

[1] Gardiner, J. Stanley (editor). *The Fauna and Geography of the Maldive and Laccadive Archipelagoes*, being an account of the work carried on and of the collections made by an expedition during the years 1899 and 1900. Vol. i, pt. i, Pls. I–V, text-figs. 1–23. Cambridge, University Press; London, C. J. Clay & Sons, 1901. Price 15*s*.

but also a serpulid worm tube, a half cocoanut shell, and a broken glass tube were appropriated. Ocypoda occurs here in two species, one of which lives and burrows in the sand, the other inland. Three grapsids are found; two Palæmonidæ, a Ligia, four Oniscidæ, and one of the Armadillidiidæ.

Recent Sporozoan Investigations.[1] — This pamphlet, which is a revision and expansion of the articles published in the *Centralblatt für Bakteriologie* (Bde. XXVII and XXVIII), gives not only the most extensive, but also the fullest and most reliable, discussion of present knowledge on this group, which has been almost neglected until the appearance of recent studies on its structure and development. The chapters of Lühe's work take up the life history (1) of the Coccidia, (2) of the Hæmosporidia (malarial parasites), (3) of the Gregarinida, Myxosporidia, and the little-known groups of Microsporidia, Sarcosporidia, and Haplosporidia. The first two sections are particularly complete and satisfactory, and it is hard to find omissions, while the discussion of the various authors cited is admirably fair. The comparative table of terms used by different writers in describing the development of Coccidia will prove very useful in view of the entire lack of uniformity as to terms employed, — a defect so universal that even successive publications of the same investigator differ in terminology. Much would be gained by the adoption of a uniform set of terms as advocated by Lühe, but unfortunately the papers which have appeared since his have added to the confusion by making further changes.

The third chapter is the least satisfactory, probably, since the field covered by it is the least well known and is consequently most difficult to bring into relation with the other groups. Furthermore, the introduction of numerous additions to the original articles, in the form of lengthy footnotes and appendices, makes the treatise difficult to use at some points; and yet the gain in accuracy compensates for the slight lack of clearness.

In one point the work must be strongly criticised: the bibliographic methods employed are antiquated and cumbersome to an extent that interferes greatly with the clearness of the text. One may well wonder how the author could have done so well with such a confused system of reference, the same papers, *e.g.*, Labbé, "Sporozoa," being referred to in three different literature lists by as many different numbers.

[1] Lühe, M. *Ergebnisse der neueren Sporozoenforschung.* Jena, 1900.

Lühe is nevertheless to be congratulated on having produced the first manual on the entire group, and in having made it a well-balanced and useful treatise.

H. B. W.

Notes. — Under the name of *Causeries Scientifiques*, the Zoölogical Society of France began last year the publication of a series of lectures on various topics of scientific importance. Among the subjects treated thus far are "Vibratile Cilia," by P. Vignon; the "Tectibranch Mollusks," by J. Guiart; and "Coccidia and their Pathogenic Rôle," by R. Blanchard. While the method of treatment shows all the advantages given by the freedom of a lecture and the articles are very readable, they are not lacking in scientific accuracy.

Stiles and Hassall (*Annual Report of the Bureau of Animal Industry* for 1899) have described carefully the mammalian lung fluke recorded previously from dog and cat in the United States and believed to be identical with the Asiatic lung fluke of man. The parasite is reported as frequent in the lungs of hogs slaughtered in Cincinnati, and the authors are inclined to regard it as identical with the Asiatic form, and hence as a real menace to the health of man in this country as it is in Asia.

Braun has added to his previous studies on the trematodes two further articles. The first, on the trematodes of the chelonians (*Mittheil. Zool. Mus. Berlin*, Bd. II, 1901), deals with twenty-two species in detail, the large majority of which are new or poorly known forms. The second paper, on the trematodes of mammals (*Zool. Jahrb.*, Syst., Bd. XIV, 1901), discusses thirteen forms, chiefly also from the Berlin collection. Noteworthy is the demonstration of the specific difference between *Opisthorchis tenuicollis* Rud. and *O. felineus* Riv., which have recently been thrown together by a number of authors. The careful comparisons between related species instituted by Braun in these studies furnish the only hope for the clearing up of this much-confused territory.

Among the parasites from Lake Nyassa recently described by von Linstow (*Jenaische Zeitschr.*, Bd. LIII, p. 408), *Tænia africana* n. sp., from man, and *Moniezia amphibia* n. sp., from the hippopotamus, are noteworthy.

The embryonic development of Anoplocephala has been worked out in detail by Saint Remy (*Arch. Parasitol.*, Vol. III, p. 292), who has observed for the first time in this group the formation of polar corpuscles.

The life cycle of the gregarines has been studied by Cuénot (*Arch. Biol.*, Vol. XVII, p. 581). He finds that the conjugation of the sporoblasts is a regular feature of the encysted condition.

Shipley has given (*Quart. Journ. Micr. Sci.*, Vol. XLIV, p. 281) an account of the structure of *Syndesmus echinorum*, an imperfectly known turbellarian which parasitizes in the sea urchin.

Loxosoma davenporti, which is described by Nickerson (*Journ. of Morph.*, Vol. XVII, p. 351), is the first representative of this genus to be recorded from this continent.

Klunzinger has published (Stuttgart, 1901) a valuable discussion on the physical, chemical, and biological causes of color in bodies of fresh water.

Elrod has published (*Trans. Amer. Micr. Soc.*, Vol. XXII, 1901) an extended account of the work done at the Montana Biological Station, Flathead Lake, during 1899. The paper gives a full description of the region, and lists of some collections made at different points, with a few striking features in the distribution of such forms as have been studied. The nine plates are good illustrations of the general appearance of the region.

Fordyce has worked up (*Trans. Amer. Micr. Soc.*, Vol. XXII, 1901) the Cladocera of Nebraska. The paper gives a valuable summary of our knowledge of the distribution of these forms in the United States, and a discussion of the conditions in the plains region, and then records important notes on the vertical distribution of species in small lakes. In all, twenty-six species were found, of which five — *Macrothrix tenuicornis*, *Dunhevedia setiger*, *Bosmina obtusirostris*, *Daphnia curvirostris*, and *Chydorus rugulosus* — are rare in the United States; *Pleuroxus truncatus* has not yet been recorded elsewhere from this country; and three — *Daphnia parvula*, *Bosmina ornamenta*, and *Leydigia fimbriata* — are new to science; descriptions and figures are given for these and the rarer forms.

There has been received through the courtesy of Dr. Mitsukuri a copy of a work entitled "Classified Catalogue of the Specimens of Vertebrates in the Collections of Kiyoiku Hakubutsukuan (Educational Museum)," published in Tokyo in 1881 by Motokichi Namiye, now curator in the Imperial University of Tokyo. The work is especially interesting as the earliest contribution of the Japanese (known to me) to the systematic zoölogy of their country. It gives a list of

1180 species of vertebrates, systematically arranged, with the vernacular names of each species. The identification is made from standard authorities and is generally correct, reflecting much credit on the patience and conscientiousness of its author, Mr. Namiye.

R. Lauterborn (*Zool. Anzeiger*, Bd. XXIV (1901), pp. 50–55) has found that shallow fresh-water ponds covered with such floating plants as duckweed, and with bottoms of black vegetable ooze often generating hydrogen sulphide, contain a very uniform and characteristic life. The flora is mostly sulphur bacteria, the almost complete absence of desmids and diatoms being very striking. The fauna contains, in addition to certain rhizopods and flagellates, no less than eighteen exclusively characteristic species of Infusoria. The author proposes to call this well-defined fauna and flora sapropelic, because of its association with decaying mud.

BOTANY.

A New Work on Gymnosperms.[1] — This is a very welcome addition to the list of books dealing with the special morphology of the higher plants.

The last five years have been notable for the number of important contributions to our knowledge of the Gymnosperms, and these recent discoveries have very materially changed the older views as to the affinities of some of them, notably the Ginkgoales. The book before us summarizes, very successfully, the results of these investigations, and should be very much appreciated by all botanical students.

While the book is largely a compilation, it includes some original work, especially in the illustrations, many of which are exceptionally good.

The book deals principally with the reproductive parts, which are treated very much in detail. While the writer agrees with the authors that an elaborate discussion of the vegetative organs was impracticable in a book of this character, still the value of the book would have been much enhanced by a proper treatment of the more

[1] Coulter, J. M., and Chamberlain, C. J. *Morphology of Spermatophytes*. New York, Appleton, 1901. 8vo, x + 188 pp., 106 figs.

important anatomical characters of the vegetative organs of the principal groups. This is especially the case in regard to the apical meristems. A single borrowed figure (Fig. 48) is hardly sufficient to make clear the characters of the apical meristems of the whole group.

Four coördinate series of living Gymnosperms are recognized, *viz.*: Cycadales, Ginkgoales, Coniferales, Gnetales. These are considered successively, the details of the gametophyte and embryo being treated very completely. On the whole, the treatment of the Cycads and Ginkgoales is most satisfactory, although including less original matter than the chapter on the Conifers. The important work of Webber, Lang, Ikeno, and Hirase are given full attention, and the chapters are fully illustrated by numerous well selected and well executed figures.

The chapter on the Conifers is to a great extent a study of *Pinus laricio*, presumably the work of the junior author. This is very complete and admirably executed. It is to be regretted, however, that the author did not include some of the numerous important American types as well as the highly specialized genus Pinus. The work hitherto done upon the genera Taxodium, Sequoia, Torreya, Thuja, etc., is very incomplete, and the inclusion of these in the book would have been a real contribution to the literature of the subject. As it is, the chapter on the Conifers must be considered much less satisfactory than those upon the other orders.

The later chapters treat very satisfactorily the fossil Gymnosperms, comparative morphology of Gymnosperms, phylogeny and geographical distribution. A valuable feature in the chapter upon the fossil forms is a series of photographs illustrating some of the Mesozoic Cycads of the United States.

The conclusions as to the origin and affinities of the Gymnosperms are essentially the same as those given by Professor D. H. Scott in his recent work on fossil plants, *i.e.*, all of the existing Gymnosperms are referable to a common ancestral stock, of filicineous origin. This conclusion, we surmise, will not be admitted, without reservation, by all botanists.

The illustrations are, for the most part, extremely good. Some of the half-tone figures, however, such as the sections of leaves shown in Figs. 5 and 47, are too blurred to have much value, and might well be replaced by good line drawings.

An admirable feature of the book is the carefully prepared bibliographies at the end of the chapters.

The book has a distinct place, and ought to be very welcome, both as a work of reference and as a stimulus to further work in this important group of plants, which are so well represented in our own flora.

D. H. C.

MacDougal's Plant Physiology.[1] — Those who have had occasion to feel the lack of a clear, concise, and up-to-date text in plant physiology will welcome the appearance of any promising book on this subject. Dr. D. T. MacDougal, of the New York Botanical Garden, is the author of a work of this character.

Dr. MacDougal points out in his preface the increased recognition of irritability in its various manifestations, due chiefly to the work of Pfeffer, and makes this the cardinal point in his arrangement of the subject-matter. The first seven chapters are devoted to a consideration of this subject in its different phases. The study of these functions and properties, or the organism and its interaction with environmental conditions, is thus the first task of the student. The composition of the plant body, exchange and movements of liquids, metabolism, growth and reproduction, are taken up in the order named. To some this order of consideration may seem open to question on the ground that the student is plunged immediately into the thick of the most obscure of plant activities, where he can find little by way of physical or chemical foundation to lend him support.

In general, the treatment of the different phases of the subject of irritability is very satisfactory. One notes with pleasure that recent work has been incorporated. A sense of being in touch with the movement of the science is worth not a little as a stimulus to the student. This prompt acceptance, however, in an elementary text, of work that has not been thoroughly verified, unfortunately has its possible disadvantages. Occasionally, without criticising a given piece of work, one hesitates to accept the author's statement of results without a grain of salt. Explanations, even though plausible, may rightly fail to win unreserved adherence until more evidence is at hand. The work of Nemec on transmission of stimuli, Loew's explanation of the action of various classes of poisons, and (in another part of the book) Nathansohn's amitotic nuclear division under the circumstances reported, illustrate the principle just enunciated. In some cases, through oversight, minor errors have crept

[1] MacDougal, D. T. *Practical Text-Book of Plant Physiology.* London, Longmans, Green & Co., 1891. 8vo, 352 pp., 159 figs.

in. The strong mineral acids in normal solutions are by no means completely dissociated in all cases (p. 53). A "normal solution" as defined in botanical literature should conform to the chemical usage (p. 51). Unfortunately, in a number of instances botanists have failed to be thus exact in the use of terms, and confusion is likely to follow. These matters will doubtless correct themselves in later editions of the book under discussion.

The chapter dealing with the composition of the plant body, written by Mr. J. E. Kirkwood and Dr. W. J. Gies, introduces the beginner to the methods of detecting and estimating many of the more important substances that may be extracted from plants. This chapter will probably prove very useful, since it furnishes in clear, brief terms much information to which the student will be glad to refer often. The chapters dealing with the chemical changes taking place in the plant, with growth and with reproduction, call forth much by way of commendation.

In view of the fact that the book is intended to contain "details of experimental methods suitable for the exact analyses requisite in research work," it demands notice as a laboratory guide. The experiments are closely interwoven throughout the book with the discussion of the various phases of the subject which they illustrate. Generally speaking, the experiments are abundant and well chosen, and the directions for work are couched in clear terms. In the manner of arranging this matter, one might perhaps see some grounds for question. The juxtaposition of experiment to principle illustrated aids a possible shrewd guess on the part of the student occasionally, but the author has generally avoided undesirable suggestion in describing the experiments. Of course, this intermingling of discussion and experiment makes the book more difficult of use as a work of reference.

As a whole the illustrations are good, whether original or borrowed. An occasional exception may be noted (Fig. 134).

An appendix contains numerical data of use to the laboratory student. Tables for converting units of various kinds into those of other systems, densities of gases, expansion of air at different temperatures, and an abridgment of Pfeffer's table of osmotic values may be mentioned.

The book has so many excellencies that it is entitled to a wide use, and the occasional errors will be remedied as later editions call the author's attention more critically to his text. R. H. T.

Ganong's Plant Physiology.[1] — Notwithstanding the recognized importance of plant physiology as a source of illuminating information on the conduct of living things, as well as a valuable means of discipline, the very scanty assortment of English texts available for classes taking up this study has been a source of inconvenience to many teachers. Laboratory manuals and concise, up-to-date treatises on the subject have both been conspicuously lacking.

Fortunately, several additions to our texts on this subject have recently been made; among these *A Laboratory Course in Plant Physiology*, by Prof. W. F. Ganong of Smith College (New York, Henry Holt & Co., 1901), outlines a series of experiments covering a school year in which eight hours are given weekly for laboratory work. Dr. Ganong has chosen experiments for their teaching value, making use of those, so far as possible, which require simple apparatus, purchasable at small expense. Inspection of the figures and descriptions given discovers much ingenuity in this selection. Since Dr. Ganong believes that in elementary courses "it is mainly qualitative results that are of value," although "the exact quantitative methods and spirit are scientifically and educationally the best," the correct use of simple apparatus is emphasized. Comment upon the experiments is chiefly by the way of suggesting to the student lines of thought and reading. When experiment is out of the question proportion is secured by references for outside reading. Much use of synoptical essays is recommended.

The suggestions are, in most cases, stimulating and within the range of the possible. When, however, the student is directed to form a clear mental picture of the molecular processes and energy involved in osmosis, one cannot refrain from asking whether the picture is to be that in the mind of Graham or that in the mind of van't Hoff. When physicists are still divided on the subject the undergraduate deceives himself who fancies that he has the data necessary for the formation of a clear mental picture.

The book is clearly the result of careful work and ample experience. It cannot but be of the greatest assistance to the teachers of plant physiology, and it deserves to be most cordially received.

R. H. T.

Notes. — Part I of a botany of the Faeröes, based upon Danish investigations, has been published, by aid of the Carlsberg fund, by

[1] Ganong, W. F. *A Laboratory Course in Plant Physiology, especially as a Basis of Ecology.* New York, Henry Holt & Co., 1901. 8vo, vi–146 pp., 35 figs.

the Nordiske Forlag of Copenhagen. Dr. Warning contributes the historical introduction, and systematic and ecological discussions are given of all but the marine algæ, which, with a comparison of land and sea vegetation and certain economic discussions, is reserved for a concluding part.

The Congo Museum of Brussels has commenced the publication, as a series of its *Annales*, of a systematic enumeration of the Congo plants collected in 1895–96 by Dewèvre. The descriptions are by De Wildeman and Durand.

Some botanical matter of interest to students of our northern vegetation is contained in No. 21 of *North American Fauna*, referring to the natural history of the Queen Charlotte Islands and the Cook Inlet region.

The willows of Alaska are discussed by Coville in the *Proceedings of the Washington Academy of Sciences*, under date of August 23.

Part VI of Dr. Rydberg's "Studies on the Rocky Mountain Flora," in the September *Bulletin of the Torrey Botanical Club*, contains a considerable number of new species, chiefly gamopetalous.

A second part of Barber's "Flora der Oberlausitz" is contained in Vol. XXIII of the *Abhandlungen der Naturforschenden Gesellschaft zu Görlitz*.

Professor Arechavaleta's flora of Uruguay, in course of publication in the *Anales del Museo Nacional de Montevideo*, has reached the group Mimoseæ.

A number of papers on the phanerogamic flora of Java, by Koorders, are contained in Vol. LX of the *Natuurkundig Tijdschrift voor Nederlandsch-Indië*.

The holly-leaved barberries, constituting the genus Mahonia, are revised by Fedde in the opening number of Vol. XXXI of Engler's *Botanische Jahrbücher*, which also contains a monograph of the orchid group Diseæ, by Schlechter.

The signatures of Vol. IV of *Pittonia*, issued September 30, contain descriptions of a number of violets and crucifers, by Professor Greene.

The origin of Liriodendron stipules is discussed by E. W. Berry in the *Bulletin of the Torrey Botanical Club* for September.

Hybrid currants are discussed by Janczewski in the July *Bulletin International de l'Académie des Sciences de Cracovie*.

A monograph of the genus Sorbus, by Hedlund, is reprinted from Vol. XXXV of the *K. Svenska Vetenskaps-Akademiens Handlingar.*

The chemistry of the bark of *Robinia pseudacacia*, by Power, and the anatomy of the bark of the same species, by Perrédès, form the subject of Nos. 20 and 21 of the *Publications of the Wellcome Chemical Research Laboratories* of London. A paper by von Schrenk, on the decay of the wood of the same tree, induced by *Polyporus rimosus*, has been separately printed from the *Twelfth Report of the Missouri Botanical Club.*

Dr. Heyl, of Darmstadt, has distributed a paper, "Ueber das Vorkommen von Alkaloiden und Saponinen in Cacteen," from the June Heft of the *Archiv der Pharmazie. Pilocereus sargentianus, Cereus pecten-aboriginum*, and *C. gummosus* were studied.

Professor Hume publishes an interesting account of *Citrus decumana* as *Bulletin 58 of the Florida Experiment Station.*

Aligera patelliformis and *Collinsia breviflora*, from California, are described in *The West American Scientist* for August, by Suksdorf.

Agave langlassei is the name applied by André, in the *Revue Horticole* for August, to a species of Manfreda from the Pacific slope of Mexico.

Professor Nelson publishes an economic treatise on the species of Bromus occurring in Wyoming, in *Bulletin No. 46 of the Wyoming Experiment Station.*

In a paper published as No. 3 of the current volume of *Proceedings of the California Academy of Sciences* Professor Peirce discusses the curious etiolated suckers which are sometimes produced by *Sequoia sempervirens.*

Separates of a paper on hybrid conifers, by Dr. Masters, have been distributed from the *Journal of the Royal Horticultural Society.*

Dr. E. F. Smith publishes an extended account of the cultural characters of four species of Pseudomonas of economic importance, in *Bulletin No. 28 of the Division of Vegetable Physiology and Pathology of the United States Department of Agriculture.*

In a paper reprinted from the *Proceedings of the Indiana Academy of Science* for 1900, Professor Arthur reaches the conclusion that the "cedar-apple" fungi, usually known by the generic name Gymnosporangium, should really be called Tremella, and he consequently

renames them under this genus, — without, however, considering the nomenclature of the many fungi usually treated as constituting the latter.

A revision of North American puffballs of the group Tylostomaceæ, by V. S. White, appears in the *Bulletin of the Torrey Botanical Club* for August.

A revision of the genus Tilletia, by Massee, is contained in the Kew *Bulletin of Miscellaneous Information* for 1899.

Professor Bailey contributes to *The World's Work* for September an illustrated account of Luther Burbank's work as a plant breeder.

Current numbers of the *Revue Générale de Botanique* contain a treatise by Jumelle on the rubber plants of northeastern Madagascar.

Raphia bast, much used by florists, is considered at length in a paper by Sadebeck, reprinted from Vol. XVIII of the *Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten.*

An illustrated paper on the anatomy of the cocoanut, by Winton, is published in the October number of *The American Journal of Science.*

The weeds of Montana are treated by Professor Blankinship in *Bulletin No. 30* of the Experiment Station of that state.

Dr. Willis, director of the gardens, has begun the publication of an irregular-period journal under the title *Annals of the Royal Botanic Gardens, Peradeniya.* The first number, issued in June last, contains a brief history of the gardens and an account of the facilities offered for research.

Volume VIII of the *Proceedings of the Iowa Academy of Sciences* contains the following botanical articles: Graw, "Preliminary List of the Flowering Plants of Adair County"; Fitzpatrick, "Juglandaceæ, Betulaceæ, and Fagaceæ of Iowa"; Mueller, "Shrubs and Trees of Madison County"; Pammel, "Thistles of Iowa, with notes on a few other species"; Faurot, "Notes on the Early Development of *Astragalus caryocarpus.*"

The initial numbers of the *Bulletin du Jardin Impérial Botanique de St.-Pétersbourg* are largely concerned with fungi and lichens. The Russian text is accompanied by abstracts in French.

An account of the Geneva meeting of the newly organized Association Internationale des Botanistes is printed in the current volume of the *Bulletin de l'Herbier Boissier.*

The World's Work for September contains an illustrated account of the Arnold Arboretum, by Sylvester Baxter.

A little handbook of nature-teaching based upon the general principles of agriculture, by Francis Watts, has been prepared at the wish of Commissioner Morris, of the Imperial Department of Agriculture for the British West Indies, and is printed by Messrs. Dulau & Co., of London.

Some phases of the conflicting interests of people who are trying to teach city pupils about nature, and those who are trying to preserve natural objects, are well presented in an article by Mrs. Britton in *Torreya* for August.

A suggestive essay entitled "How shall a Young Person study Botany?" by Professor Beal, is reprinted from the *Proceedings* of last winter's conference of the New York State Science Teachers' Association.

Another of the interesting and well illustrated memoirs on plant ecology that the *Botanical Gazette* is bringing out is by Professor Bray, and deals with western Texas.

Phytogeographic nomenclature, discussed by Flahault in the July *Bulletin of the Torrey Botanical Club*, was the subject of an extended paper by Clements at the recent Denver meetings.

A paper on some changes effected in plants by frost is published by Lapeyrère in the current volume of the *Bulletin de la Société de Borda*, of Dax.

An essay on old herbaria, by Matouschek, is printed in Vol. XXXII of the *Mittheilungen aus dem Vereine der Naturfreunde in Reichenberg* for 1901.

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